
Chapter 4



4. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

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4.1 CHAPTER INTRODUCTION

This chapter provides information describing the affected environment of forested state lands in western Washington, including the policies, procedures, and strategies that govern their management. The affected environment sections describe the current condition of the forested state trust lands against which the proposed Alternatives are evaluated. The following resources are discussed:

- Forest Structure and Vegetation (Section 4.2)
- Riparian Areas (Section 4.3)
- Wildlife (Section 4.4)
- Air Quality (Section 4.5)
- Geomorphology, Soils, and Sediment (Section 4.6)
- Hydrology (Section 4.7)
- Water Quality (Section 4.8)
- Wetlands (Section 4.9)
- Fish (Section 4.10)
- Public Utilities and Services (Section 4.11)
- Cultural Resources (Section 4.12)
- Recreation (Section 4.13)
- Scenic Resources (Section 4.14)
- Cumulative Effects (Section 4.15)

The environmental effects related to each of the above resource areas are discussed by resource area following the presentation of the affected environment for each resource area. The environmental effects sections provide the scientific and analytical basis for the comparison of alternatives presented in Chapter 2. Because of the long length of Section 4.2, Forest Structure and Vegetation, this section is presented in a somewhat different format than the others. After first presenting general background material, the affected environment and the associated environmental effects are presented separately for each of six major subsections.

Many resource areas refer to information presented in the affected environment sections of the Forest Resource Plan Environmental Impact Statement (DNR 1992a) and the Habitat Conservation Plan Environmental Impact Statement (DNR 1996). However, some information has been updated, and other subject areas (e.g., soil productivity, recreation) not covered in either the Habitat Conservation Plan or the Forest Resource Plan Environmental Impact Statements have been added.

The purpose of this analysis is to specifically evaluate whether the alternative policies and strategies proposed for managing DNR westside trust lands, alone or together, would have a significant adverse effect on the environment. The Forest Resource Plan and the Habitat Conservation Plan Environmental Impact Statements provide useful benchmarks for evaluating the effects of the 2003 Sustainable Harvest Calculation level.



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This is a programmatic Environmental Impact Statement (i.e., non-project under the State Environmental Policy Act). Consequently, the analysis for each resource area focuses specifically on evaluating the impacts of the policies and procedures that are being modified under the Alternatives. Conclusions are based on a qualitative analysis, supported by quantitative data where available and appropriate.

For some resource areas, changes in policy, procedure, or operational management proposed under the Alternatives are different for the Olympic Experimental State Forest compared to the other five westside planning units. Consequently, the likelihood of adverse effects may also be different. In these instances, the Olympic Experimental State Forest is discussed separately from the other westside planning units.

The temporal scale for resource analyses is both the short term (10 years) and long term (30 to 64 years). These time periods reflect the planning period for the Sustainable Harvest Calculation and the lifespan of the Habitat Conservation Plan. Data are presented by decade for many resources.

The analyses presented in this chapter found that there are different levels of risk associated with the various Alternatives. Where this is the case, the Alternatives are ranked. Ranking does not imply that the Alternative with the highest risk rating would result in a significant adverse impact. In many cases, the higher ranking simply implies that greater care would be taken in implementing a strategy and higher levels of investment would be needed to ensure that careful planning, implementation, and monitoring are included at the project level.



4.2 FOREST STRUCTURE AND VEGETATION

4.2.1 Summary of Effects

This section analyzes the environmental effects on forest structure, old forests, carbon sequestration, and threatened and endangered plant species. The analysis examines the current and proposed changes to policy and procedures under the different Alternatives. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also assesses relative risks among Alternatives that are illustrated using modeling outputs.

Alternatives 1 and 4 would provide more old forest and would entail less risk of adversely affecting threatened, endangered, and sensitive plants than the other Alternatives. However, Alternatives 1 and 4 would result in more dense forest stands that achieve lower tree growth rates and are more susceptible to damage from insects and disease. They rely on more passive management and would require less investment for forest management. Alternatives 2 and 3 are ranked intermediate on all factors and would also require an intermediate level of investment needed for successfully implementing the management strategies associated with these Alternatives and achieving the projected level of harvest.

Alternatives 5 and 6 would have fewer restrictions on areas available for stand management and timber harvest and would apply more intensive management strategies than the other Alternatives. Management proposed under Alternatives 5 and 6 would result in higher rates of tree growth, forests that are less susceptible to insect and disease damage, and higher levels of long-term carbon storage. Alternative 6 also ranks relatively high for maintaining stands with old forest characteristics. Alternatives 5 and 6 would entail more risk of adversely affecting threatened, endangered, and sensitive plants due to more harvest and harvest-related disturbance.

4.2.2 Introduction

This section describes the existing forest structure and vegetation resources on DNR-managed state trust lands in western Washington, and assesses potential effects to these resources resulting from changes to DNR's management policies under the proposed Alternatives. During the public scoping process, concerns were raised about the effects of the proposed Alternatives on forest conditions, growth and yield, forest health (including fire, insect, and disease damage, windthrow, and the spread of noxious weeds), and on old forests. The following areas were assessed for the effects of proposed policy changes to the management of forest resources:

- Forest Condition – Change in the proportion of forest acreage within stands at different development stages; changes in the quantity and types of forest management activities.
- Growth and Yield – Annual volume harvested over the (64-year) analysis period; even flow of timber harvest over the analysis period; changes to standing volume of trees over time; and changes to forest stand development stages as an indicator of tree growth.



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- Forest Health – Changes to relative forest stand density as an indicator of stand vigor and fire risk as it relates to harvest intensity.
- Old Forest – Acres of forest with old forest stand structure characteristics.

Analysis of effects to the forest vegetation resources focuses on the approximately 1.4 million acres of westside forested state trust lands. Each of the six proposed Alternatives presents a broad range of strategies for implementing DNR's 70-year Habitat Conservation Plan (DNR 1997). The analysis covers the period between 2004 and 2067, and is to be re-assessed at periodic time intervals within this period.

4.2.3 Current Conditions

4.2.3.1 Physical Setting

The forested state trust lands in western Washington span vegetation zones from near sea level to mountaintops. Vegetation zones represent areas of similar environmental settings (soils, climate, elevation, aspect, and disturbance regimes). Vegetation zones tend to occur sequentially up mountain slopes, depending upon changed conditions at these elevations—generally, changes in moisture and temperature levels (Franklin and Dyrness 1988). Vegetation zones are named for climax tree species that would dominate the area in the absence of wildfire, timber harvest, or windstorms, or until such a disturbance occurs. However, plant communities associated with a specific seral stage may occupy the site at any given time, depending on the forest's development.

The **western hemlock zone** covers approximately 71 percent of the westside forested trust lands. It extends from sea level to about 2,000 feet in elevation. Tree species include western hemlock, Douglas-fir, western red cedar, Pacific silver fir, grand fir, red alder, and bigleaf maple. Portions of the Puget Sound lowlands (see Chapter 3) located in the Olympic Mountains' rain shadow have gravelly glacial soils and relatively low rainfall. These areas often support lodgepole pine along with Douglas-fir.

The **Sitka spruce zone** is found in a narrow band along the Pacific Coast and in “fingers” up coastal river valleys where the climate is mild and moist year-round. Ten percent of the DNR-managed forestland in western Washington is in the Sitka spruce zone. Mixed conifer forests, consisting of Sitka spruce, western hemlock, western red cedar, Douglas-fir, grand fir, Pacific silver fir, lodgepole pine, and red alder occur in this zone, though in different proportions than in the western hemlock zone.

The **Pacific silver fir zone** occupies 16 percent of the westside state trust lands. This zone generally occurs between 2,000 and 4,000 feet in elevation where the cool, wet climate results in a relatively short growing season. Pacific silver fir, noble fir (south of Stevens Pass), Douglas-fir, yellow cedar, western red cedar, and Sitka spruce are tree species that characterize this zone. Less than 2 percent of westside trust lands are in the high elevation forest zones, which extend from about 4,000 feet in elevation up to the “tree line.”



4.2.3.2 Forest Conditions

Disturbance has long been a factor in Pacific Northwest forests. The extensive Douglas-fir forests seen by European settlers in the nineteenth century were born of fire (Agee 1993, Franklin and Dyrness 1988). Wind was a major disturbance factor, especially in coastal Sitka spruce and higher elevation Pacific silver fir and alpine forests, where the moist conditions generally limited fire spread (Agee 1993). In higher elevations, snow-downed trees opened up the forest for regeneration. Insects and disease were also disturbance agents.

Disturbance after European settlement has been primarily through timber harvest, land clearing, and fire. Most of the westside state trust lands have been logged at least once in the past 100 years (DNR 1997).

Conditions that followed clearcutting (i.e., the removal of all trees) differ greatly from the conditions following most natural disturbances in terms of the structural legacies remaining after natural types of disturbance. Currently, DNR retains legacy trees (sometimes called reserve trees) in all harvests. Conversely, past clearcutting did not leave a legacy of overstory trees.

Clearcutting, as originally conceived, removed all trees—merchantable as well as snags, cull trees, seedlings, saplings, tops, and branches—in order to start a new rotation with even-aged trees that would fully occupy the site. Following the timber harvest, large woody debris was lost with intensive slash disposal practices such as broadcast burning or piling and burning. With the exception of stands regenerated within the past 15 to 20 years and those destroyed by fire, most of the forest stands found on western Washington trust lands were regenerated from past clearcutting.

4.2.3.3 Current Forest Management and Harvest Levels

Since 1996, and the adoption of the Habitat Conservation Plan, all regeneration harvests on DNR-managed westside trust lands have followed the same policy and procedural direction as Alternative 1 (No Action) as described in Chapter 2.

Table 4.2-1 shows the average annual acres of forest stand management activities that occurred on western Washington trust lands for the years 1997 through 2002.

Table 4.2-2 displays the acres of precommercial thinning (thinning done before the trees are merchantable) that have occurred since DNR began implementation of the Habitat Conservation Plan.



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Table 4.2-1. Average Annual Acres of Forest Management Activities, by Planning Unit, 1997 through 2002

Planning Unit	Fertilization Acres per Year	Site Preparation					Vegetation Management	
		Aerial Herbicide Application	Ground Herbicide Application	Mechanical	Pile and Burn	Broadcast Burn	Aerial Herbicide Application	Ground Herbicide Application
		Acres per Year	Acres per Year	Acres per Year	Acres per Year	Acres per Year	Acres per Year	Acres per Year
Straits	0	0	15	1	9	0	0	343
North Puget	1,114	338	0	0	6	10	704	1,533
South Puget	113	0	0	0	10	0	31	253
Columbia	0	573	123	40	80	5	1,473	260
South Coast	0	23	13	11	144	0	603	574
Olympic Experimental State Forest	0	0	0	0	20	0	0	60
Total	1,227	934	151	52	269	15	2,810	3,023

Data Source: DNR Planning and Tracking database

Area fertilized includes both application of biosolids and aerial fertilizer application in North Puget and South Puget planning units. Area fertilized updated from e-mail communication from Carol Thayer, 7/24/03.

Table 4.2-2. Acres Pre-commercially Thinned on Westside State Trust Lands by Habitat Conservation Plan Planning Unit, 1996 through 2002

Planning Unit	Average Acres/Year Precommercially Thinned	Total Acres Precommercially Thinned 1996-2002
Straits	624	3,743
North Puget	3,782	22,691
South Puget	830	4,982
Columbia	751	4,504
South Coast	1,604	9,621
Olympic Experimental State Forest	5,034	30,203
Total	12,624	75,745

Data Source: DNR Planning and Tracking database

DNR is required to provide for long-term stable harvest of timber measured in volume according to Policy Nos. 4 and 5 (DNR 1992b). State law mandates the periodic recalculation of this sustained yield harvest (formerly Revised Code of Washington 79.68.040, recodified at Laws of 2003, Ch. 334, sec. 555(3)). In 1996, the Board of Natural Resources adopted an annual sustainable harvest level of 655 million board feet for the forested state trust lands statewide. This equates to approximately 570 million board feet as the sustainable harvest level for westside state trust forests.



During the past 5 years (1998 to 2002), an average of just over 430 million board feet of timber per year has been harvested from westside trust lands. The majority of the harvest volume removed was in the Central (Grays Harbor, Lewis, Pacific and Thurston counties) and Northwest Regions (Skagit, Snohomish, and Whatcom counties). Each of these two regions produced about 28 percent of the total 5-year timber volume yield. The Southwest Region (Clark, Cowlitz, Klickitat, Pacific, Skamania, and Wahkiakum counties) contributed about 19 percent of the volume. The Olympic (Clallam, Grays Harbor, and Jefferson counties) and South Puget Sound (King, Kitsap, Lewis, Mason, and Pierce counties) Regions produced 15 and 14 percent of the total yield, respectively.

Table 4.2-3 displays the total current standing forest volume by land class. Approximately 24 percent of trust land timber volume is located in the “uplands with general objectives” land class, 44 percent and 32 percent of the volume are in the “uplands with specific objectives” and “riparian” land classes, respectively (see Appendix B for a description of land classes).

Table 4.2-3. Standing Timber Volume for Western Washington State Trust Lands by Land Class

Land Classification	Volume (billion board feet)
Uplands with General Objectives	12.3
Uplands with Specific Objectives	16.7
Riparian	23.0
Total	52.0
Data Source: Model output data (stand development stages)	

4.2.4 Forest Structure, Growth, and Yield

4.2.4.1 Affected Environment

Stand development stages describe the structural conditions and developmental processes within a forest stand. Stand structural development stages represent a continuum rather than precise structural stages. The stages used in this analysis are adapted from three separate sources (Brown 1985, Carey et al. 1996, Johnson and O’Neil 2001). The stages are an attempt to better describe predicted forest development under management intended to increase structural complexity, including dead trees (snags) and down logs in order to support biodiversity.

“Stand development stages” differ from the “age classes” used to approximate forest structure for the Habitat Conservation Plan. Age class was the best available data at the time. However, age class is not a reliable indicator of stand structure. This fact was recognized in the Habitat Conservation Plan, and methods were put in place to change management focus from age to structure (DNR 1997, page IV-180).

Many factors affect the rate at which a stand develops, including site conditions, tree genetics, the tree species used to initiate regeneration after harvest, the density of the new



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trees, natural disturbance, and management activities (Franklin et al. 2002, Oliver and Larson 1996). While stand development stages can be roughly tied to the age of a stand, there are too many variables to expect a forest to develop along a predictable timeline.

The stand development stages used in this analysis are based on:

- tree size,
- percent of canopy closure,
- canopy layers,
- abundance of dead or decadent trees, and
- abundance of dead down wood.

Descriptions of the stand development stages used in this analysis are provided in Appendix B, Section B.2.1.2. Table 4.2-4 displays the percent distribution of stand development stages on westside forested trust lands by planning unit. The majority of DNR-managed forests are Douglas-fir or western hemlock stands in the sapling, pole, and large tree exclusion stage. About 45 percent (622,000 acres) of the forested lands are in the large-stem exclusion stage (fully stocked stands dominated by 20- to 29-inch trees). About 35 percent (474,000 acres) of the forested lands are in the sapling and pole exclusion stages dominated by even-aged smaller stemmed trees. Approximately 3 percent (42,000 acres) of the forest is in understory reinitiation. Nine percent (125,000 acres) of the forests are in developed understory, botanically diverse, and niche diversification development stages that provide progressively more internal stand biodiversity with each development stage. Less than 1 percent (8,000 acres) of the westside state trust lands are in old natural forest and fully functioning stages.

Ecosystem initiation stages are open, newly regenerated stands that are actively growing. As stands develop into the sapling exclusion stage, pole exclusion, and large tree exclusion stages, competition for direct sunlight, nutrients, water, and space increases (Oliver and Larson 1996). These stands are nearing, or have exceeded, full site occupancy. When growing space is fully occupied, growth declines. The understory reinitiation stage develops as a result of in-stand mortality or silvicultural thinning. Trees that achieve dominance have more growing space. As tree density is reduced, growth of the dominant trees increases. In multi-storied stands such as developed understory, botanically diverse, niche diversification, and fully functional structure stages, the primary factors that influence growth are age, tree species, site, spacing, and density. Growth rates in these stands would be variable. Where density is high, growth rates would be slowed. In mature stands, growth may slow as a factor of tree age. In stands where density is variable, potential growth may be lower due to low stocking.

“Forest growth and yield” refers to the change in standing tree volume over time, and the amount of timber harvested over time. Changes in forest conditions, such as in the distribution of stand development stages or species composition can reflect changes in potential growth and yield.

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Table 4.2-4. Stand Development Stages in Westside Forested State Trust Lands, by Planning Unit

		Planning Unit					Total Percent of Forest Trust Lands	Total Acres
		Straits	North Puget	South Puget	Columbia	South Coast	OESF ^{1/}	
Forest Stand Development Stage	Percent of Total Acres	Percent of Total Acres	Percent of Total Acres	Percent of Total Acres	Percent of Total Acres	Percent of Total Acres		
Ecosystem Initiation	10	8	9	9	9	6	8	114,552
Sapling Exclusion	16	17	16	12	12	26	17	229,980
Pole Exclusion	11	15	16	17	14	28	18	243,856
Large Tree Exclusion	58	45	51	51	53	21	45	621,779
Understory Reinitiation	1	6	1	1	1	1	3	34,941
Developed Understory	<1	<1	<1	<1	<1	<1	<1	4,178
Botanically Diverse Stage	2	5	4	6	6	11	6	87,043
Niche Diversification	1	3	3	3	4	5	3	46,161
Fully Functional	<1	<1	<1	1	<1	1	<1	6,150
Old Natural Forests	<1	<1	<1	<1	<1	<1	<1	2,064
Total Percent	100	100	100	100	100	100	100	
Total Acres Planning Unit	110,222	381,515	141,843	267,530	232,931	256,659		1,390,703

Data Source: Model output data – stand development stages

^{1/} OESF = Olympic Experimental State Forest

Note: Numbers rounded; when added, may not equal 100%.

Characteristics that affect growth and yield are the density and spacing of trees in stands, the development stages of stands, and the site productivity of stands. The effects of the proposed Alternatives are measured by how management activities change stand density and the stand development stage. Stand development stages represent stand structure and are used to index growth (change in forest volume over time) and yield. Comparing the resulting development stage distribution among Alternatives provides a means for summarizing changes in stand structure, growth rates, and yields. Current amounts of each stand development stage are displayed in Table 4.2-4.



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4.2.4.2 Environmental Effects

Table 4.2-5 summarizes the proposed policy, procedure, and operations changes that would affect the forest conditions, standing volume, and distribution of forest stand development stages over the westside trust lands. Appendix C provides an overview of current policy and procedures, and Chapter 2 provides further detail on proposed changes.

Table 4.2-5. Policy, Procedure, and Operational Changes that Affect Forest Structure, Growth, and Yield

Policy and Procedure Changes Proposed	Alternative					
	1	2	3	4	5	6
Policy No. 4 – Sustainable, Even-flow Timber Harvest		X	X	X	X	X
Policy No. 5 – Harvest Levels Based on Volume					X	X
Policy No. 6 – Western Washington Ownership Groups			X		X	X
Policy No. 11 – Management of On-base Lands				X	X	X
Policy No. 30 – Silviculture Activities; Policy No. 31 – Harvest and Reforestation Methods						X
Task 14-001-010 – Maintenance of Mature Forest Components		X	X	X	X	X
Procedure 14-004-120 – Management Activities within Spotted Owl Nest Patches, Circles, Designated Nesting, Roosting, and Foraging and Dispersal Management Areas		X	X	X	X	X
Procedure 14-005-020 - Identification and Prioritization of Stands for Regeneration Harvest		X	X	X	X	X
Operations – Increased Resources needed to Identify Unstable Slopes —Level of Use of Fertilization, Thinning, Planting		X	X		X	X

The effect of the changes to Procedure 14-004-120 and Task 14-001-010 would be an increase in land available for forest management compared to Alternative 1 (No Action) (see Appendix B, Table B-4: Acres of Land Deferred from Timber Harvest and Acres by Land Classification for Each Alternative, for changes in amounts of deferrals for each Alternative). Increasing available land would allow for an increase in total harvest activities across the land base and a resultant increase in harvest levels. Forest management and harvest rates in “Uplands with General Objectives” and “Uplands with Specific Objectives” land classes would increase under Alternatives 2, 3, 4, 5, and 6. As available or ‘on-base’ land increases, so would the distribution of the harvest over the differing land classes (see Table 4.2-6).

All Alternatives would implement DNR’s Habitat Conservation Plan strategies. As a result of these strategies, it is expected that over time conditions on state trust forests would:

- increase the area of more structurally complex forests, and
- increase standing forest inventories.

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Table 4.2-6. Average Distribution of Harvest within Land Classes

Alternative	Land Classification			Total
	Uplands with General Objectives	Uplands with Specific Objectives	Riparian	
	Percent of Total Harvest	Percent of Total Harvest	Percent of Total Harvest	
1	56%	37%	8%	100%
2	41%	47%	12%	100%
3	44%	42%	14%	100%
4	52%	37%	11%	100%
5	34%	50%	16%	100%
6	28%	37%	35%	100%

Source: DNR OPTIONS model results (timber flow levels)

Structurally complex forests are categorized here as the developed understory, botanically diverse, niche diversification, fully functional, and old natural forests stand structure stages (Appendix B).

Model projections for all the Alternatives display an increase in standing volume (Table 4.2-7) and more diverse forest conditions in the future (see Figures 2.6-2, 2.6-3, and 2.6-4 in Chapter 2, and Table 4.2-8). Modeled changes in the distribution of stand development stages are discussed at greater length in Sections 4.2.5.2 and 4.4.4.1.

All Alternatives would result in increases in standing tree volume over time, except Alternative 3, which is modeled as resulting in slightly less standing volume in 2067 than in 2004 (Table 4.2-7). All Alternatives are less than Alternative 1 (No Action) in standing volume increases. However, the importance of standing volume is its relationship to the amount of timber harvest (flow) over time, and the structural conditions within a forest.

Model output indicates that all Alternatives would maintain a relatively constant timber harvest flow over the planning period 2004 through 2067 (Figure 4.2-1). In other words, there are no dramatic declines or booms in harvest flow. Even Alternative 3, which produces the most variation in the first half of the planning period, begins to produce a steadier flow towards the end of the planning period. Modeled declines in timber harvest flow from the initial decades are not a result of declines in standing forest volume or inventory, because inventory would increase under all Alternatives except Alternative 3 (Table 4.2-7). Modeled declines in timber harvest flow under any Alternative reflect a transition period that each Alternative passes through, from the current inventory level to a new standing inventory level in the future. This transition and new stand inventory would be determined by changes to policies on sustainable even-flow, the method of calculation (value versus volume), ownership groups, and maturity criteria. The levels of harvest would be a result of different amounts and areas of available land for forest management, as well as the policies mentioned above.



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Table 4.2-7. Percent Change in Standing Volume from Base Year 2004 by Alternative through the Analysis Period

Year Modeled	Alternative					
	1	2	3	4	5	6
2008	4%	2%	1%	4%	1%	2%
2013	9%	5%	1%	9%	3%	4%
2031	25%	13%	5%	23%	6%	7%
2048	35%	14%	5%	32%	15%	10%
2067	39%	10%	-3%	33%	16%	6%

Source: Model output data (stand development stages)

Table 4.2-8. Comparison of Forest Stand Development Stage Distribution (percent of forested acres) in 2067

Forest Stand Development Stage	Existing Condition (2004)	Alternative					
		1	2	3	4	5	6
Ecosystem Initiation	8%	11%	13%	14%	10%	17%	13%
Sapling Exclusion	17%	5%	10%	13%	6%	13%	9%
Pole Exclusion	18%	11%	18%	17%	12%	19%	13%
Large Tree Exclusion	45%	25%	23%	21%	23%	20%	19%
Understory Reinitiation	3%	9%	9%	11%	10%	11%	11%
Developed Understory	<1%	1%	1%	1%	1%	<1%	1%
Botanically Diverse	6%	21%	14%	11%	18%	8%	9%
Niche Diversification	3%	10%	8%	7%	10%	9%	16%
Fully Functional	<1%	7%	4%	5%	10%	4%	9%
Old Natural Forest	<1%	<1%	<1%	<1%	<1%	<1%	<1%

Source: Model output data (stand development stages)

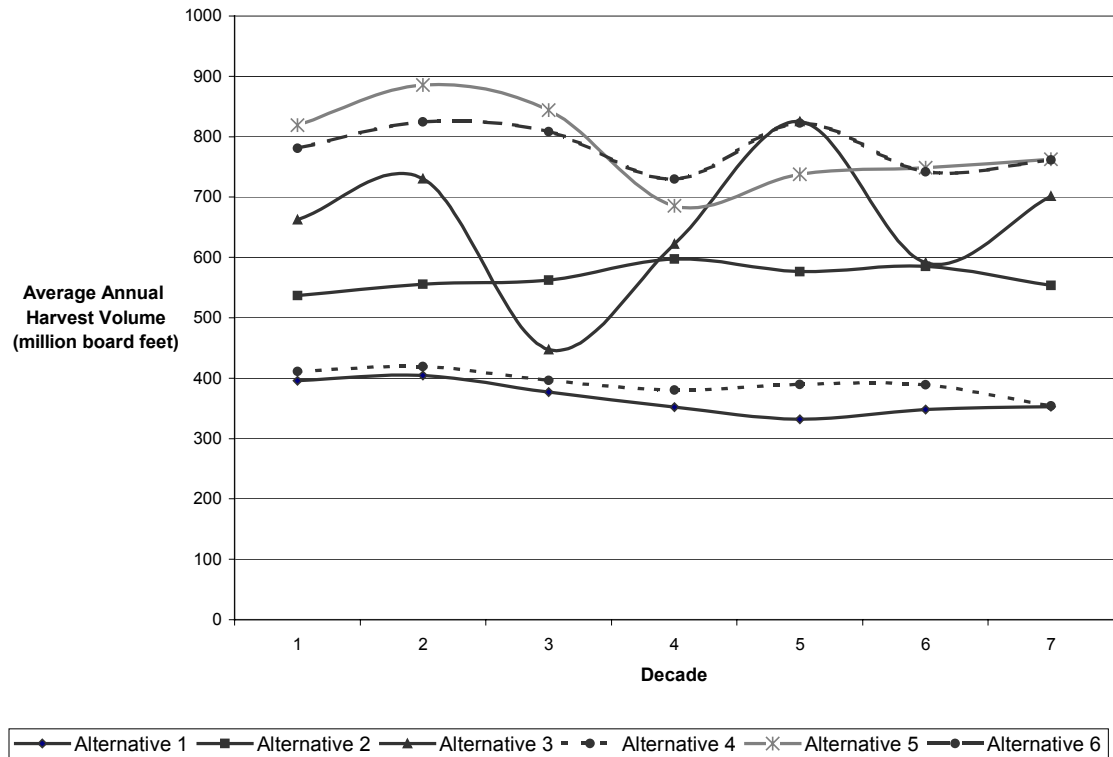


Figure 4.2-1. Average Annual Western Washington State Trust Land Timber Harvest Volume per Decade Over the Planning Period (2004-2067)

Data Source: Model output data (timber flow levels)

The Alternatives would result in differing distributions of stand development stages over time, differing timber harvest flows and levels, and differing inventories of tree volumes. However, this analysis identified no significant adverse environmental impacts on forest conditions or on the potential growth and yield of the forest as a result of the proposed policy and procedural changes in any of the six Alternatives.

4.2.5 Old Forest

4.2.5.1 Affected Environment

There is no single definition of old forest, sometimes referred to as old growth. Depending on the definition of this term, its meaning varies. For some individuals, the definition of old forest is deeply rooted in science; for others, old forest simply means big trees. To many people, old forests have spiritual or aesthetic values, or are important for recreation. The intangible benefits of old forest will be the focus of this subsection measured by the presence of stands with old forest characteristics. Refer to Section 4.4 (Wildlife) for a discussion of old forest as wildlife habitat.



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In this section, various definitions to describe old forests are used, which include:

- Forest stands older than 150 years of age
- Forest stands that have various old forest characteristics, labeled here as “**structurally complex forests**” that include the stand development stages of developed understory, botanically diverse, niche diversification, fully functional, and old natural forests

In the Olympic Experimental State Forest, 20 percent of DNR-managed trust forests are managed for old forest conditions (DNR 1997, page IV.88). The Habitat Conservation Plan glossary provides the following definition for old forest (listed under the term old-growth forest).

A successional stage after maturity that may or may not include climax old-growth species; the final seral stage. Typically contains trees older than 200 years. Stands containing Douglas fir [*sic*] older than 160 years, which are past full maturity and starting to deteriorate, may be classified as old forest. DNR’s GIS forest classification for old forest is: a dominant DBH (diameter at breast height) of 30 inches or greater; usually more than eight dominant trees/acre; three or more canopy layers with less than complete canopy closure; several snags/acre with 20 inch dbh or greater; and several down logs per acre with a 24 inch dbh or greater.”

According to Forest Resource Plan Policy No. 14, about 2,000 acres of old forest (stands larger than 80 acres and greater than 160 years old) are currently deferred from timber harvest in Old Growth Research Areas. DNR Geographic Information System data show about 2,000 acres of old natural forests, as defined by stand development stage class (Table 4.2-4). These stands have high levels of structural complexity, are greater than 250 years old, and are located on the westside trust forestlands. These acres are distributed in Columbia (700 acres), North Puget (600 acres), South Coast (30 acres), and Olympic Experimental State Forest (700 acres) planning units.

DNR estimates there are about 145,000 acres of structurally complex forests on state trust forestlands in western Washington. The distribution of these structurally complex acres among the planning units is provided in Table 4.4-1. Field observations and local research indicate some level of agreement with these estimates; however, the criteria used to identify old forests and structural complexity will vary depending upon the purpose. DNR’s stand development stage classification uses criteria principally from studies in hemlock/Douglas-fir forests and may not accurately categorize other forest types such as the spruce forests in the Olympic Experimental State Forest.

4.2.5.2 Environmental Effects Associated with Old Forest

Proposed changes to policy and procedures among the Alternatives that would affect old forest are summarized in Table 4.2-9.

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Table 4.2-9. Policy and Procedure Changes that Affect Old Forest on State Trust Lands

Policy Change Proposed	Alternative					
	1	2	3	4	5	6
Task 14-001-010 – Maintaining Mature Forest Components (50/25 strategy)		X	X	X	X	X
Procedure 14-006-090 – Legacy and Leave Tree Levels		X	X	X	X	X
Manage 10-15% of each Planning Unit in Mature Forest Component					X	X
Maintain All Stands Greater than 150 Years Old				X		

In all Alternatives, regardless of management strategy, stands that represent old forest conditions would increase substantially over the 64-year planning period. Figure 4.2-2 graphically displays the distribution of structurally complex forest at the end of the planning period. Figure 4.2-3 displays acres of forests 150 years old or greater occurring at the end of the first and last decades of the analysis period. A greater long-term increase in structurally complex forests is projected under Alternatives 1 and 4 than under the other Alternatives (Figure 4.2-2). The passive approach to timber management in Alternative 4, setting aside all 150-year-old stands, and the longer average maturity criteria (80 years), would result in the highest percent of the area in stands with old forest characteristics. There would be a smaller increase in stands with old forest characteristics under Alternatives 2 and 6. The fewest acres with old forest are projected under Alternatives 3 and 5.

4.2.6 Forest Health

4.2.6.1 Affected Environment

Forest Resource Plan Policy No. 9, Forest Health, and Guideline 14-004-030, Assessing and Maintaining Forest Health, both incorporate forest health practices into forest management, stressing prevention through early detection and management such as the maintenance of appropriate species and tree density in state forests.

Growing space is the sum of conditions needed for tree growth. Relative density indicates the amount of growing space occupied by each tree within a forest stand (relative density is a ratio based on a sampling of tree measurements/counts). Often used as a tool to determine when thinning is needed to maintain steady tree growth in the stand, relative density can also be used as an indicator of stand health. As competition among trees for growing space increases, relative density increases and tree vigor declines.

Increased susceptibility to insects and disease in densely stocked forest stands is, in part, a function of the way a tree allocates its food resources or nutrients. Although allocation of food may vary among tree species and different tree ages, most trees have a set priority for allocating resources. Maintenance of the tree's existing living tissue (tree growth) and reproduction are of higher priority than the production of resistance mechanisms to ward



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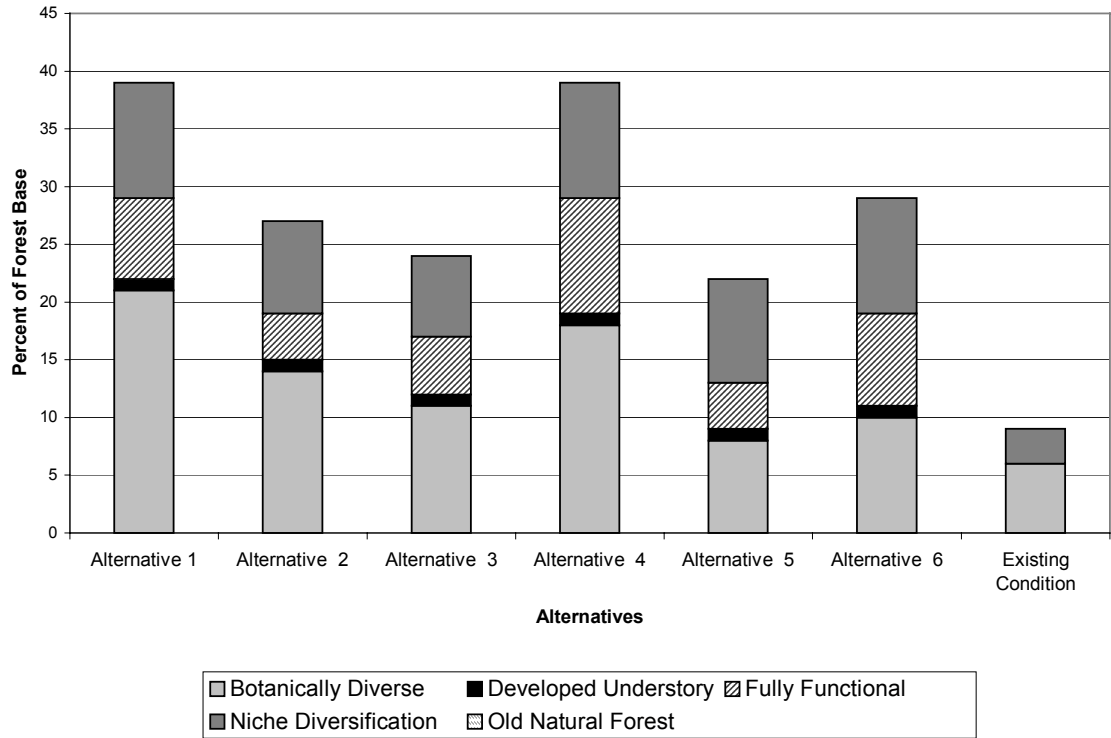


Figure 4.2-2. Percent Distribution of Forests with Structural Complexity Characteristics of Old Forest at Year 2067
Data Source: Model output data (stand development stages)

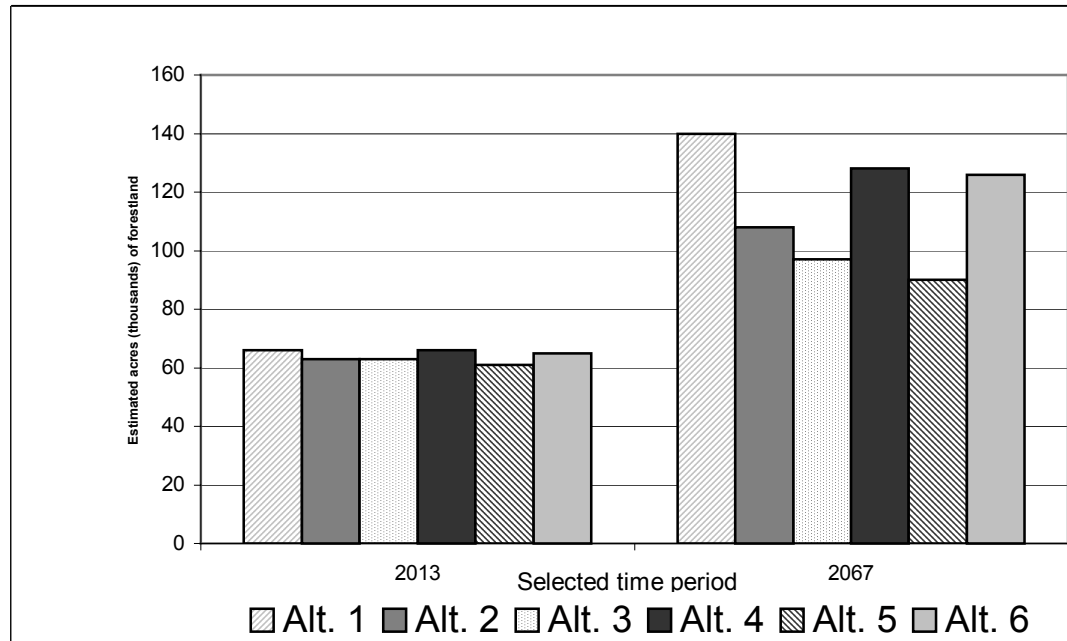


Figure 4.2-3. Acres of Old Forest by Alternative at Years 2013 and 2067
Current conditions are estimated at 60,000 acres of old forest is represented as forests 150 years and greater. Data Source: Model output data (stand development stages)

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off insects and disease (Oliver and Larson 1996). High density does not ensure poor stand health, because it is not specifically the cause of stress and mortality. Insects, disease, and environmental factors that cause mortality may affect a stand at any time. However, forest stands with decreased vigor are more susceptible to these stresses (Drew and Flewelling 1979). The point at which density-caused mortality occurs serves as an indicator of forests at increased risk for forest health concerns.

The relative density at which competition-related mortality occurs varies by tree species.

- Western hemlock and Douglas-fir trees dominate the majority of the forest stands on westside trust lands.
- Douglas-fir dominated stands begin to experience density-related mortality at a relative density of 50, although some stands do not show mortality until they reach a relative density of 70 (Curtis 1982, Bailey et al. 1998).
- Western hemlock stands begin to experience density-related mortality at a relative density of 55 (USDA Forest Service 2002a).
- Red alder stands begin to experience density-related mortality at a relative density of 44 (Puettmann et al. 1993).

Table 4.2-10 shows the relative density level when the susceptibility for competitive mortality increases for the three major tree species in westside trust forestlands.

Approximately 226,000 acres of Douglas-fir stands, 374,000 acres of western hemlock stands, and 140,000 acres of red alder stands are nearing or at increased risk to mortality, based on elevated relative density. Thinning to maintain growth has the secondary effect of reducing stocking to increase stand vigor.

Table 4.2-10. Forests at or Above the Relative Density Levels at Which Tree Mortality Occurs by Tree Species

Major Dominate Tree Species	Relative Density When Density Related Mortality May Begin	Acres on DNR Westside Trust Land	Percent of Total Forested Area
Douglas-fir	50 and above	226,000	16
Western hemlock	55 and above	374,000	27
Red alder	44 and above	140,000	10
Total		740,376	53

Data Source: Model output data (stand development stages)

The 2002 aerial survey showed that the major causes of damage in western Washington forests include hemlock looper and black bear (DNR 2003). Hemlock looper is a tree defoliator that is associated with multi-storied old forest. Its primary hosts are western hemlock, Douglas-fir, and western red cedar. Outbreaks of hemlock looper have been quite extensive in recent years, presumably due to drought.

Black bear damage increased from about 38,000 acres in 2001 to 172,000 acres in 2002. Damage to sapling and pole-sized stands can be high. Bears strip the bark to eat the cambium layer, sometimes girdling the tree.



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Laminated root rot poses a major threat to its most economically important host, second-growth Douglas-fir. The disease causes root decay, which can cause significant growth reduction, and makes trees susceptible to blowdown (Thies et al. 1995). Recently cut stumps are infected by spores. The disease can remain viable for decades in old stumps and roots. Thinning can worsen the problem, causing the disease to spread to uninfected trees. Black-stain root disease is spread by insects, primarily root-feeding bark beetles such as *Hylastes nigrinus*. Trees damaged by logging operations, including thinning, have an increased risk of infection. Soil compaction may also play a role (Otrošina and Ferrell 1995). Treatment of root disease generally removes the diseased trees. The area is typically then reforested with a less susceptible tree species (DNR 1997).

Bark beetles are usually associated with events that kill or weaken trees such as windthrow or drought. When populations increase, bark beetle will attack healthy trees.

FIRE RISK

The operation of logging equipment can ignite a forest fire, especially when surface fuels (slash) associated with logging are present. Additionally, intensive management requires greater access, which may increase in human-caused fires. Fire intensity and expected fire spread rates increase in areas adjacent to harvest. This analysis uses the level of harvest intensity by Alternative to evaluate fire risk.

4.2.6.2 Environmental Effects Associated with Forest Health

There are no proposed changes in policy, procedures, or tasks among the Alternatives that specifically address forest health. However, proposed policy changes that affect harvest intensity and, consequently, forest structures across the landscape can affect forest health. (Refer to Appendix D for a discussion on harvest intensity.)

Under Alternative 1, there would be a slight reduction in the acres of western hemlock and red alder stands with a high relative density. However, the amount of Douglas-fir-dominated stands with a high relative density would increase over time (Table 4.2-11). Alternatives 2, 3, and 4 are projected to reduce acres with high relative densities by a similar amount, between 7 to 12 percent (Table 4.2-11). The majority of the reduction would occur in western hemlock-dominated stands, though some reduction in the Douglas-fir and red alder stands is also projected. Intensive management that includes regeneration harvest and aggressive thinning strategies under Alternatives 5 and 6 would result in the greatest reduction of acres with high relative densities, a reduction of nearly half (Table 4.2-11). The majority of the reduction would occur in western hemlock-dominated stands, and to a lesser degree, Douglas-fir and red alder stands.

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Table 4.2-11. Percent of Total Forested Acres with Elevated Relative Density Levels over the Planning Period by Alternative^{1/}

Alternative	Dominant Tree Species	Analysis Period					
		2004	2008	2013	2031	2048	2067
1	Douglas-fir	16%	16%	16%	19%	19%	20%
	W. Hemlock	27%	29%	30%	32%	30%	25%
	Red Alder	10%	9%	9%	8%	8%	8%
	Total Acres	53%	54%	54%	59%	58%	52%
2	Douglas-fir	16%	15%	14%	13%	14%	15%
	W. Hemlock	27%	28%	29%	31%	27%	22%
	Red Alder	10%	9%	8%	6%	7%	7%
	Total Acres	53%	52%	51%	50%	49%	43%
3	Douglas-fir	16%	14%	12%	15%	17%	15%
	W. Hemlock	27%	29%	30%	27%	25%	19%
	Red Alder	10%	10%	9%	7%	7%	7%
	Total Acres	53%	52%	52%	49%	49%	41%
4	Douglas-fir	16%	15%	14%	17%	15%	14%
	W. Hemlock	27%	27%	28%	30%	27%	23%
	Red Alder	10%	9%	8%	7%	8%	7%
	Total Acres	52%	51%	50%	54%	51%	45%
5	Douglas-fir	14%	11%	9%	10%	9%	10%
	W. Hemlock	26%	26%	23%	16%	13%	11%
	Red Alder	10%	8%	7%	7%	7%	6%
	Total Acres	50%	45%	40%	32%	30%	27%
6	Douglas-fir	16%	15%	13%	14%	12%	12%
	W. Hemlock	25%	25%	26%	23%	21%	17%
	Red Alder	10%	9%	7%	5%	6%	5%
	Total Acres	51%	49%	46%	49%	40%	34%

^{1/} See Table 4.2-10 for relative density levels when tree mortality occurs by tree species
Data Source: Model output data (stand development stages)

The high levels of moderate to heavy thinning associated with Alternatives 5 and 6 could increase the risk of tree mortality and growth loss from root disease (Thies and Sturrock 1995) and windthrow if harvest is not properly designed and implemented. Bark beetle tree mortality is generally associated with weakened or dead trees. Windthrow would increase the risk of beetle population increases and consequent tree mortality from bark beetles. Therefore, additional resources and staff would need to be committed to ensure that harvests are carefully planned and administrated.

The risk for hemlock looper outbreak may increase slightly under all Alternatives because all Alternatives promote forest multi-layered canopy forest structure; however, looper is generally associated with old forests and drought (DNR 2003).

Alternatives that feature repeated thinning entries (such as Alternative 6) would increase the risk of diseases spread through wounds made by logging equipment (Otrosina and Ferrell 1995).



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Alternatives that have the greatest amount of forest in the sapling and pole exclusion stages would have the greatest risk for bear damage. At the end of the planning period (2067), Alternatives 1 and 4 would have the least area at risk of bear damage, with 16 and 18 percent of the westside trust lands in sapling and pole exclusion stands, respectively (Table 4.2-8). Alternatives 2, 3, 5, and 6 would have a greater percent of the area in these stand development stages—between 22 and 32 percent of westside trust forestlands would be in sapling and pole exclusion stand development stage at the end of the planning period.

FIRE RISK

Harvest intensity under Alternatives 1, 2, and 4 would be relatively low. The risk for wildfire associated with operator fires and logging residue would be similar to the existing risk under these Alternatives. Harvest intensity under Alternative 3 would fluctuate over time. Regeneration harvest would be higher than the other Alternatives in the first decade but would decrease over time. Fire risk under Alternative 3 would be highest in those years when harvest intensity is high (Appendix D). Alternatives 5 and 6 would have the highest harvest intensity levels over the duration of the planning period, with Alternative 5 slightly higher than Alternative 6. The higher number of harvested acres would increase the risk of a fire compared to the other Alternatives. Under all Alternatives, fire risk would be mitigated by treatment of logging slash after the timber has been harvested if it is determined to be an extreme hazard (DNR 1992b). Slash treatments are designed to burn, remove, or rearrange the slash to reduce fire risk. In periods of high fire risk, logging operations are normally suspended, thereby mitigating fire risk during logging operations.

4.2.7 Carbon Sequestration

Carbon, primarily in the form of carbon dioxide, is one of the major greenhouse gases that are being released into the atmosphere (McPherson and Simpson 1999). The global carbon cycle involves the earth's atmosphere, fossil fuels, the oceans, and the vegetation and soils of the earth's terrestrial ecosystems. Gases that make up the earth's atmosphere, such as carbon dioxide, methane, nitrous oxide, and water molecules, trap the sun's heat, creating a natural "greenhouse effect" that makes life on earth possible (McPherson and Simpson 1999). These gases are released into, and removed from, the atmosphere by a variety of natural sources and sinks.

Forest lands have the capacity to absorb large quantities of carbon dioxide emissions and sequester carbon for potentially long periods of time (Binkley et al. 1997). Forests have the potential to store a great deal more carbon than they currently do (Harmon 2001), which, in turn, may temporarily slow the increase of atmospheric carbon dioxide concentrations. Although studies have shown that intensive forest management can lead to increased rates of carbon dioxide sequestration (Binkley et al. 1997, Schroeder 1991), other research suggests that not all forestry-related projects are equally likely to sequester carbon and that some may actually release carbon to the atmosphere (Harmon 2001).

The term "carbon sequestration" refers to the removal of carbon dioxide from the atmosphere, and the long-term storage of carbon as trees or as products such as lumber



(U.S. Department of Energy, Office of Fossil Energy 2001). Forest carbon sequestration refers to the annual rate of storage of carbon dioxide in both aboveground and belowground biomass over the course of a growing season (McPherson and Simpson 1999).

4.2.7.1 Affected Environment

Approximately 80 percent of westside trust forestlands are in a competitive exclusion stage, with 35 percent in sapling and pole exclusion, and 45 percent in large tree exclusion. During the sapling and pole exclusion stages, trees begin to compete for space, light, and nutrients; ultimately the taller, faster-growing trees become dominant, causing mortality in the suppressed, smaller trees and creating the first cohort of small snags. Following mortality, decay will cause a release of carbon back to the atmosphere. Additional releases of carbon will come from those trees that are suppressed and ultimately die during the large tree exclusion stage. These larger stems, trees over 20 inches diameter at breast height, have sequestered considerably more carbon than those stems in the sapling and pole exclusion stages. An acre of trees in the sapling and pole stage may accumulate between 5 and 10 tons per acre while a stand with fewer but larger trees may accumulate carbon at two to three times that rate (McPherson and Simpson 1999). Based on research by Schroeder (1991), thinning of very dense younger stands could increase carbon storage by concentrating growth into crop trees that eventually are used to produce lumber and other products.

Research conducted by Haswell (2000) indicates that lengthening rotation increases the aboveground carbon storage. Extending the rotation age from 40 to 65 years resulted in a 41 percent increase in aboveground carbon storage. Also, larger diameter trees achieved through longer rotation lengths are more likely to produce wood products, such as lumber used in building construction, that will store carbon over long periods of time. The management regime affects the nature of the forest products carbon pool (short rotations tend to produce a higher fraction of short-term products such as paper and cardboard).

4.2.7.2 Environmental Effects Associated with Carbon Sequestration

Alternatives with longer rotation lengths and intermediate thinnings could increase aboveground carbon storage compared to Alternatives with shorter rotation lengths and no thinnings. Alternatives 1 and 4 are projected to produce more large trees (trees greater than 20 inches diameter at breast height) and, therefore, are likely to store more carbon on site than the other alternatives. Alternative 6 has the next highest distribution of forested acres with large trees, which would likely result in the next highest amount of carbon sequestered and stored on site, followed by Alternatives 2, 3, and 5. However, long-term storage is also affected by the decay of trees and down wood.

While Alternatives 1 and 4 would grow more large trees, they would also harvest less wood than other Alternatives and use less thinning to reduce within-stand competition and tree mortality. More young trees would die and decay, releasing carbon into the atmosphere. Alternatives that concentrate tree growth into crop trees that are harvested and converted to wood products used in buildings would store carbon for longer periods.



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In terms of carbon sequestered in lumber and other wood products over the period of analysis, Alternatives 6 and 5 are projected to produce the highest harvest volumes per decade. Much of this volume is projected to be from large trees by the end of the planning period (2067). Harvested trees are likely to be processed into long-term wood products, such as lumber used in building and home construction, and would maintain sequestered carbon well beyond the planning period. Alternatives 3, and 2 produce lower harvest volumes than Alternatives 6 and 5. Alternatives 4 and 1 are projected to produce the lowest harvested volumes. Alternatives 1 to 4 are likely to store less carbon in the long term than Alternatives 6 and 5.

4.2.8 Threatened, Endangered, and Sensitive Plants

4.2.8.1 Affected Environment

The Washington Natural Heritage Program maintains a list of threatened, endangered, and sensitive plant species known to occur in each county. The list is derived from a comprehensive Geographic Information System database of known occurrences of threatened, endangered, and sensitive plants in the state. Appendix D contains a list of threatened, endangered, and sensitive species that either occur or may occur in the general area of forested trust lands. The list is compiled from threatened, endangered, and sensitive species lists for each county that includes the westside state trust forestlands. The table also includes the habitat requirements for each species and known occurrences of threatened, endangered, and sensitive plants on the state trust lands.

As shown in Appendix D, many threatened, endangered, and sensitive plant habitats, such as alpine, beach, exposed rock, or exposed grassy bluff, are not likely to be affected by harvest or harvest-related activities. Other habitats such as meadows, prairies, or forest openings may not support trees for harvest but may be adjacent to harvest areas and could potentially be affected by harvest activities. The species that occur in forested habitat, including microhabitats in forests such as forest openings, have a higher likelihood of being affected by harvest or harvest-related activities.

No comprehensive inventory of threatened, endangered, and sensitive plants exists for the DNR trust lands. The known occurrence lists do not represent a full inventory. A list of potential species for individual projects can be developed from the Washington Natural Heritage Program database on threatened, endangered, and sensitive species by county.

DNR management activities on all forested trust lands follow Forest Resource Plan Policy No. 23, Endangered, Threatened, and Sensitive Species. The policies and regulations that govern the management of threatened, endangered, and sensitive plants on forested trust lands can be found in Appendix C. DNR's rare plant database is generally reviewed for known occurrences of listed threatened, endangered, and sensitive plants during planning of timber management activities (personal communication with F. Caplow, Washington Natural Heritage Program). There are no DNR procedures requiring review of known occurrences or avoidance of threatened, endangered, and sensitive plants during operations. However, the Habitat Conservation Plan's protection of rare habitats, cliffs, talus slopes,



combined with wetland and riparian management measures, provide some incidental protection. The limitations of activities in these areas reduce the likelihood of physically disturbing threatened, endangered, and sensitive plant populations that may exist in these areas.

4.2.8.2 Environmental Effects Related to Threatened, Endangered, and Sensitive Plants

Direct effects to threatened, endangered, and sensitive plants include physical damage or destruction to the plant due to harvest or related activities. Indirect effects include changes in the micro-environment, such as changes in canopy (i.e., available sunlight), changes in hydrology, and increases in competition from weeds or other native species. The range of effects is wide and varied because there are many threatened, endangered, and sensitive plant species with different habitat requirements and life histories. Therefore, each species would potentially have a different sensitivity to particular disturbances. For example, while one species may benefit from additional light due to a reduced canopy cover, another could be negatively affected by direct sunlight.

Comparison of Alternatives

The Alternatives considered in this analysis do not propose to change any policies or procedures for managing threatened, endangered, and sensitive plants. The treatment of these plants is identical under all Alternatives. The difference in effects of the Alternatives would, therefore, be a function of acres of harvest in habitats that may contain threatened, endangered, and sensitive plants. Because the locations of these plant populations are not necessarily known, it is assumed that more harvest and harvest-related disturbance has a greater probability of physically disturbing such populations or their habitat. For this analysis, areas that may experience harvest activities and where threatened, endangered, and sensitive plants can occur are considered. These include both riparian and upland areas.

RIPARIAN AREAS

Differences among Alternatives in policies and procedures for managing Riparian Management Zones would affect the amount of harvest within the Riparian Management Zone boundaries. The level of harvest or harvest-related activities in the riparian land class is expected to be related to the potential to disturb or harm a threatened, endangered, and sensitive plant population. More harvest per acre has more potential to physically disturb a plant population. Alternative 6 has the highest level of harvest activities, as much as 35 percent of the riparian area may be affected based on model results (Table 4.2-12). Therefore, Alternative 6 is expected to have the highest probability of affecting threatened, endangered, and sensitive plant populations in riparian or wetland habitats. This is followed by Alternative 5 at approximately 13 percent per decade, Alternative 3 at 8 percent per decade, and Alternative 2 at 7 percent per decade. Alternative 4 at 5 percent per decade and Alternative 1 at 3 percent per decade have the lowest total harvest in riparian areas.



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UPLAND AREAS

Diversity of habitats appears to be relatively limited in a fully stocked, young forest (Spies and Franklin 1991), and species diversity is likely to be low. With time, a forest can form a well-developed, multi-layered understory and can become botanically diverse (Carey et al. 1996, Franklin and Spies 1991). A natural consequence of a stand aging is an increase in structural complexity and microsite diversity. Diversity in microsites offers a diversity of habitats and opportunity for species with different habitat requirements to exist. As a stand ages beyond a young forest with a closed canopy, species diversity is expected to increase (Scientia Silvica 1997).

While it is not known whether habitats for specific threatened, endangered, and sensitive plants are developed as harvested areas regenerate, it is expected that as stands develop structural complexity, a more botanically diverse understory would develop, possibly including microhabitats that could potentially support these species. Forest stand development stages that have had sufficient time to develop structural complexity, an understory, and botanical diversity include botanically diverse, niche diversification, fully functional, and old natural forest. The effects to these forest stand development stages are discussed in Section 4.2.4.2 of this document and summarized in Table 4.2-12.

The model results show a difference between Alternatives in the acreage that is expected to be in botanically diverse stand development stages by the end of the analysis period (2067). Alternatives 1 and 4 would have the largest portion of DNR forest trust lands (38 and 39 percent of acres, respectively) in botanically diverse stand development stages by the year 2067. Therefore, Alternative 1, current operations, and Alternative 4, with longer rotations to retain old forests, are expected to have developed the largest area with diversity of habitats in forested areas.

Table 4.2-12. Harvest in Riparian Zones, and Percent of Forest with Botanical Diversity, by Alternative

Alternative	Average Percent of Riparian Land Class Impacted per Decade by Harvest Type			Total	Percent of Forested Acres (Upland and Riparian) with Botanical Diversity ^{4/} in 2067
	Low Volume Removal Harvest ^{1/}	Medium Volume Removal Harvest ^{2/}	High Volume Removal Harvest ^{3/}		
1			3%	3%	38%
2	1%	2%	3%	7%	27%
3	2%	3%	4%	8%	23%
4			5%	5%	39%
5	5%	3%	5%	13%	21%
6	23%	5%	8%	35%	34%

Data Source: Model output data – timber flow levels and stand development stages

1/ Less than 11 thousand board feet per acre volume harvests

2/ Between 11 and 20 thousand board feet per acre volume harvests

3/ Greater than 20 thousand board feet per acre volume harvests

4/ Includes botanically diverse, niche diversification, fully functional, and old natural forest stages

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Alternatives 1 and 4 are followed by Alternative 6 with 34 percent and Alternative 2 with 27 percent of acres that would be expected to be in stand development stages with high levels of botanical diversity by the year 2067. Alternatives 3 and 5 (23 and 21 percent of acres, respectively) are expected to have the fewest acres in these stand development stages.

In summary, for both riparian and forest habitats, Alternatives 1 and 4 are expected to have the least potential to affect threatened, endangered, and sensitive plants. For riparian plants, Alternatives 5 and 6 would have the most potential to physically disturb threatened, endangered, and sensitive plants and their habitats. For forested areas, Alternatives 3 and 5 are expected to provide the fewest acres of diverse habitat to support threatened, endangered, and sensitive plants. In all Alternatives, site-specific analysis would determine the likely effects of individual harvest proposals.



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4.3 RIPARIAN AREAS

4.3.1 Summary of Effects

This section analyzes the environmental effects on riparian resources. The analysis examines the current policy and procedures and the future changes to them proposed under the Alternatives. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are qualified using modeling outputs.

The management strategies proposed under the six Alternatives would not result in any probable significant adverse impacts on riparian resources beyond existing conditions and those anticipated in the Habitat Conservation Plan Environmental Impact Statement. However, the different levels of management activities under each of the Alternatives are likely to result in greater potential of adverse impacts for those Alternatives with higher levels of silvicultural activities than for those with more passive management. These impacts, both beneficial and negative, vary when analyzed in the short term versus the long term. Alternative 6 is projected to develop more “functional” forest area in riparian areas; however, these projections are the outcome of an active management program of thinnings, snags, and down woody debris treatments.

Each of the Alternatives proposes different amounts of harvest activities in the riparian land class (Appendix B). The estimated average activity level of Alternative 5 is 13 percent per decade; Alternative 3 is 8 percent per decade; Alternative 2 is 7 percent per decade; Alternative 4 is 5 percent per decade; and Alternative 1 is 3 percent per decade.

The average estimated level of activity under Alternative 6—35 percent per decade—represents substantially higher levels than the other Alternatives, although the majority of the harvest area in Alternative 6 is low-volume removal harvests. Alternative 6 model results show a high level of activity within the riparian areas. It appears likely that the modeling outputs for Alternative 6 over-estimates the amount of allowable activity in the riparian areas. Upon examination, the problem is not with the fundamental policy direction in Alternative 6, but rather the outcome of initial modeling assumptions. The model may overestimate the rate and intensity of harvest activities in riparian areas. Model assumptions will be reviewed for the Final Environmental Impact Statement.

4.3.2 Introduction

This section describes the riparian ecosystem and its various functions, the current condition of riparian areas on DNR-managed westside trust lands, the types of allowable activities in Riparian Management Zones, and the likely effects of the Alternatives on the condition of riparian areas. Although riparian areas include instream habitat and stream channels, adjacent floodplains, and wetlands (which often include seeps and springs), this section focuses on stream riparian areas. A discussion of riparian buffer protection for wetlands can be found in Section 4.9 (Wetlands).



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A wide variety of hydrologic, geomorphic, and biotic processes determine the character of riparian areas. Riparian areas have distinctive resource values and characteristics that make them important zones of interaction between terrestrial and aquatic ecosystems.

On DNR-managed westside trust lands, riparian functions are protected through the use of Riparian Management Zones, where the amount and type of management activities that can be implemented are restricted. During the scoping for this Environmental Impact Statement, the amount of activity in Riparian Management Zones was identified as an important issue, particularly concerning activities for restoration of targeted riparian functions.

4.3.3 Affected Environment

This section provides a short discussion of riparian functions. It also discusses the current condition of riparian areas on DNR-managed westside trust lands.

4.3.3.1 Riparian Functions

The most important recognized functions of stream riparian areas include large woody debris recruitment, leaf and needle litter recruitment, stream shade, microclimate, stream bank stability, and sediment control. To understand the impacts of various management actions, it is important to understand these functions. Many authors have reviewed these functions (e.g., Murphy and Meehan 1991, Forest Ecosystem Management Assessment Team 1993, Spence et al. 1996, DNR 1996 [pages IV-145 to IV-175], Washington Forest Practices Board 2001 [pages 3-36 to 3-40]), and their work provides the basis for this analysis.

Large Woody Debris Recruitment

Large woody debris includes entire trees, rootwads, stems, and larger branches. Riparian areas are an important source of large woody debris that can be recruited to the stream channel. Large woody debris recruitment originates from a variety of processes, including tree mortality (toppling), windthrow, undercutting of stream banks, debris avalanches, deep-seated mass soil movements, and redistribution from upstream (Swanson and Lienkamper 1978). The loss of large woody debris results from breakage, decomposition, and redistribution downstream.

Numerous studies have shown that large woody debris is an important component of fish habitat (Swanson et al. 1976, Bisson et al. 1987, Naiman et al. 1992) and that it is critical for sediment retention (Keller and Swanson 1979, Sedell et al. 1988), gradient modification, structural diversity (Ralph et al. 1994), nutrient production and retention (Cummins 1974), and protective cover from predators.

There is a strong relationship between channel width and the size (diameter, length, and volume) of large woody debris that forms a pool, an important component to fish habitat (Bilby and Ward 1989). Large woody debris that is large enough to form a pool is referred to as “functional large woody debris.” Even larger woody debris that is also effective in trapping smaller more mobile pieces of large woody debris (i.e., forming logjams), and



more likely to have long-term stability is sometimes referred to as “key piece large woody debris.” It is considered by some to be a better measure of the important wood recruitment sizes (DNR 1995).

The relationship between large woody debris size and function needs to be evaluated when considering activities in buffer strips. Riparian Management Zones need to ensure not only an appropriate amount or volume of wood, but wood of sufficient size to serve as both functional and key pieces (Murphy 1995). Consequently, the size distribution and type of trees present in the riparian zone are important factors for maintaining adequate large woody debris recruitment. Measurable contributions of wood from second-growth riparian areas are documented to take anywhere from 60 to 250 or more years depending on region and size of stream (Grette 1985, Bilby and Wasserman 1989, Murphy and Koski 1989). Conifers tend to have a larger potential maximum size and decompose more slowly than hardwoods, but they also tend to grow more slowly than most western Washington hardwoods.

Leaf and Needle Litter Production

In aquatic systems, some vegetative organic materials (such as algae) originate within the stream while others (such as leaf and needle litter) originate from sources outside the stream. Stream benthic communities (e.g., aquatic insects) are highly dependent on materials from both sources. The abundance and diversity of aquatic species can vary significantly depending upon the total and relative amounts of algae, leaf, and litter inputs to a stream (IMST 1999).

Most of the vegetative organic debris input into small- and medium-size streams comes from outside the stream, through the annual contribution of large amounts of leaves, cones, wood, and dissolved organic matter (Gregory et al. 1991, Richardson 1992). In contrast, wide high-order streams with higher levels of direct sunlight, or low-order streams with an open riparian canopy, produce more algae. The source and level of organic debris input can change. For example, as a riparian stand ages, the amount of litter-fall increases (IMST 1999).

The importance of leaf and needle litter input varies among streams, but it can provide up to 60 percent of the total energy input into stream communities (Richardson 1992). Litter deposited into small, steep-gradient streams in forested areas high in a watershed is generally transported downstream, because higher gradient streams are less likely to retain deposited organic material until it has decomposed. Therefore, small (low-order) streams are important sources of nutrients and contribute substantially to the productivity of larger streams in the lower reaches of a watershed (IMST 1999).

Stream Shade

Stream shade is an important factor affecting stream temperature. Several factors dictate the heat balance of water in streams, including air temperature, solar radiation, evaporation, convection, conduction, and advection (Brown 1983, Adams and Sullivan 1990). Stream



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temperatures have a natural tendency to warm from the headwaters of a stream to the ocean (Sullivan et al. 1990, Zwieniecki and Newton 1999). However, seasonal and daily cycles produce a high degree of variability in stream temperature.

Summertime temperatures are of particular interest in western Washington. During the summer, when stream temperatures are the highest, the major factors affecting stream temperature are warmer air temperatures, increased direct solar radiation, and decreased stream flows (Beschta et al. 1987). Forest management activities can have the greatest effect on direct solar radiation by reducing or promoting shade. Shade cannot physically cool a stream down, but it can prevent further solar heating and thus maintain the water temperature from groundwater inputs or tributaries (OFPACSW 2000). Shade provided by riparian vegetation has been shown to be successful in minimizing or eliminating increases in stream temperature associated with timber harvest (Brazier and Brown 1973, Lynch et al. 1985). Other factors that affect shading include stream size and stream orientation, local topography, tree species, stand age, and stand density.

Microclimate

Microclimates tend to vary greatly across the landscape. Each microclimate is a collection of variables that are highly dependent on local conditions. Important components of microclimate include solar radiation, soil temperature, soil moisture, air temperature, wind velocity, and air moisture or humidity (reviewed in Spence et al. 1996, Forest Ecosystem Management Assessment Team 1993).

Removing stream-side vegetation may result in changes in microclimatic conditions within the riparian zone. These changes can influence a variety of ecological processes that may affect the long-term integrity of riparian ecosystems (Spence et al. 1996). For example, many of the variables considered in microclimate studies (air temperature, humidity, wind velocity) are also variables that affect water temperature (Sullivan et al. 1990).

Microclimate is also important to stream/riparian species other than fish, such as amphibians.

In general, due to their low-lying position on the landscape, riparian areas tend to be cooler than the surrounding hill-slopes, especially during the night. Because riparian areas are adjacent to water bodies, they often have a higher relative humidity under the canopy than similar upslope areas. This increase in humidity combined with shading effects can cause intact forested riparian areas to have a moderating effect on microclimate (Beschta and Boyle 1995).

Sediment Control and Stream Bank Stability

The delivery of fine and coarse sediment to streams can lead to stream channel instability, pool filling by coarse sediment, creation of spawning gravels, or introduction of fine sediment to spawning gravels. Sediment can be delivered to the aquatic system as surface erosion (fine sediment) generated from harvest units, skid trails, and roads or stream crossings within the riparian area. It can also be delivered as landslides or debris torrents (coarse and fine sediments), whether initiated naturally or in harvested areas on unstable



slopes. Additional discussion of surface erosion and landslides is provided in Section 4.6, Geomorphology, Soils, and Sediment.

Timber harvest activities can alter watershed conditions by changing both quantity and size distribution of sediment delivery to streams. Streamside buffer strips can significantly reduce the amount of coarse sediment that reaches a stream, by filtering it through the vegetation. Similarly, buffer strips can limit the amount of fine sediment that reaches a stream from surface erosion by physically obstructing or inhibiting the movement of the sediment into the water. The ability of riparian buffer strips to control sediment inputs in this manner depends on several site characteristics, including the presence of vegetation or organic litter, slope, soil type, and drainage characteristics.

Landslides are important to riparian areas as a disturbance mechanism and are episodic sources of large woody debris as well as fine and coarse sediment in streams. They are part of the natural processes that create and/or maintain riparian functions. Debris slides are the most common landslides on steep forestlands. More intense types of slides include debris torrents and debris flows, which may follow existing stream channels. Major storms can increase the rate and intensity of landslides. Sidle et al. (1985) summarized several studies indicating that slope stability depends partly on reinforcement from tree roots, especially when soils are partly or completely saturated. In addition to having significant impacts on the stream channel, debris torrents can also affect riparian buffer functions and streamside forests when bank scour removes streamside vegetation.

The stability of stream banks is largely determined by the size, type, and cohesion of the soil profile; vegetation cover; root mass; and the amount of bedload carried by the channel (Sullivan et al. 1987). Riparian vegetation can provide hydraulic roughness that dissipates stream energy during high or overbank flows, which further reduces bank erosion. In most cases, vegetation immediately adjacent to a stream channel is most important in maintaining bank integrity (Forest Ecosystem Management Assessment Team 1993). However, in wide valleys with shifting stream channels, vegetation throughout the floodplain or channel migration zone may also be important over longer time periods.

4.3.3.2 Current Riparian Conditions

Historically, Pacific Northwest forests (including riparian areas) were a mosaic of different forest types and ages, and large areas of old forest were common (Franklin et al. 1981). However, compared to upland forests, riparian areas are more frequently disturbed by fluvial processes and can have more diverse stands than upland areas (Agee 1988). National Marine Fisheries Service (1996) considers watersheds with riparian areas at least 50 percent similar to the potential natural community as being “properly functioning.” Those between 25 to 50 percent similar are considered “at-risk,” and those with less than 25 percent are considered “not properly functioning.” Such ratings tend to be relative, not absolute. There is also substantial variability depending upon the nature and distribution of the riparian communities by stream reach.



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Figure 4.3-1 and Table 4.3-1 depict the distribution of stand development stages in the riparian land class for the six westside planning units. The riparian land class includes stream and wetland riparian buffers plus their associated wind buffers. Under the Habitat Conservation Plan some locations require wind buffers; for the purpose of uniform analysis, wind buffers are assumed to be required. The stand development stages are described in detail in Appendix B.

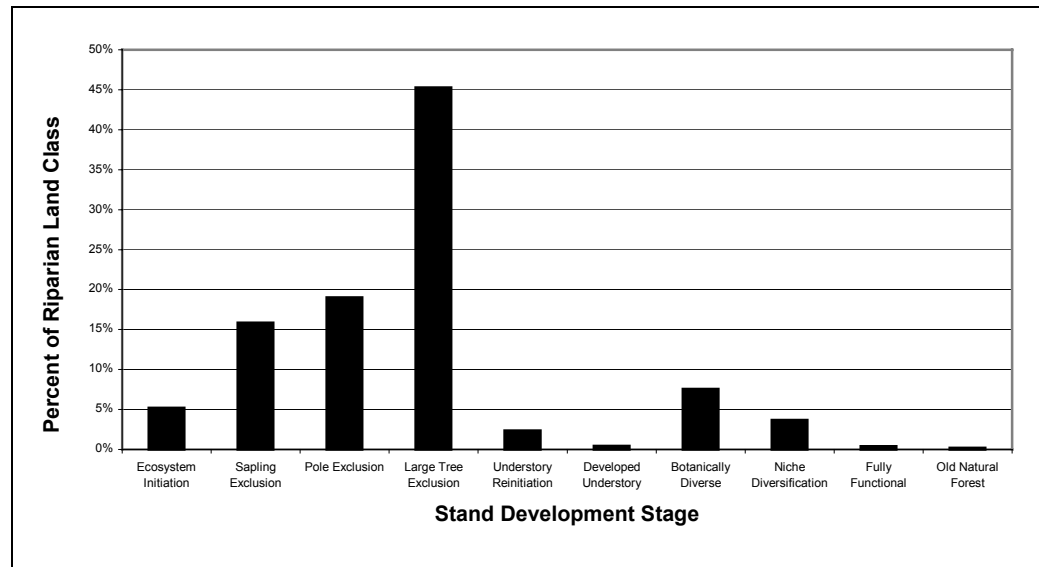


Figure 4.3-1. Distribution of Stand Development Stages within the Riparian Land Class on DNR Westside Forest Trust Lands

Data Source: Model output data – stand development stages

In general, the distribution of stand development stages for riparian areas within the westside planning units is skewed towards sapling, pole, and large tree exclusion stand developmental stages. Some planning units (e.g., the Olympic Experimental State Forest) also have a relatively high proportion of the ecosystem initiation developmental stages. With the exception of the Olympic Experimental State Forest, 51 to 65 percent of riparian areas by planning unit are within the large tree exclusion stage. Within this stand development stage, dominant trees are 20 to 29 inches in diameter and canopy closure is greater than 70 percent. Dominant trees in this stand development stage are sufficiently large to provide functional large woody debris and shade to streams of moderate or smaller size (up to about 60 feet in width), based upon a relationship observed by Bilby and Ward (1989).

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Table 4.3-1. Distribution of Stand Development Stages (Carey et al. 1996) Within Riparian Areas^{1/} Among the Six Westside Planning Units

Stand Development Stage	North Puget	South Puget	Columbia	South Coast	Olympic Experimental State Forest	Strait s	Total
Ecosystem Initiation	5.4%	5.6%	5.7%	4.9%	4.6%	5.4%	5.2%
Sapling Exclusion	13.6%	12.9%	12.3%	11.6%	25.1%	12.9%	15.9%
Pole Exclusion	14.4%	16.7%	17.5%	15.5%	29.0%	9.9%	19.0%
Understory Reinitiation	5.5%	1.4%	1.2%	1.4%	1.6%	2.2%	2.3%
Large Tree Exclusion	51.0%	55.1%	52.4%	55.2%	21.0%	65.1%	45.3%
Developed Understory	0.6%	1.0%	0.5%	0.3%	0.1%	0.9%	0.4%
Botanically Diverse	5.5%	3.8%	6.4%	6.8%	12.8%	2.2%	7.5%
Niche Diversification	3.3%	3.5%	3.4%	4.1%	4.3%	1.5%	3.7%
Fully Functional	0.3%	0.1%	0.3%	0.1%	1.1%	0.0%	0.4%
Old Natural Forest	0.3%	0.0%	0.3%	0.0%	0.3%	0.0%	0.2%
Total Stream Associated Riparian Acres^{2/}	78,143	28,509	78,202	72,893	61,497	16,064	335,308
Total Riparian Land Class Acres	92,724	34,606	86,443	80,966	111,308	20,684	426,731

Data Source: Model output data – stand development stages

1/ Percentages based upon the total Riparian Land Class acreage, which include modeled buffers for riparian areas adjacent to types 1-4 streams and wetlands plus associated wind buffers.

2/ Acreage does not include wetland and wind buffer areas.

In contrast, the riparian land class tends to be deficient in “very large” trees (more than 30 inches in diameter at breast height) found in the botanically diverse, niche diversification, fully functional, and old natural forest stand development stages. Very large trees are needed to supply large woody debris and shade to larger streams and rivers or are needed in the outer portions of the Riparian Management Zones. At increasing distance from a stream, a tree must be larger and taller to effectively supply large woody debris to a stream (McDade et al. 1990). A similar relationship occurs for providing shade. The riparian land class in the westside planning units range from approximately 4 to 19



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percent of these stand development stages. Notably, the Olympic Experimental State Forest has a higher percentage of stands in the very large stages compared to the other planning units. The Straits Planning Unit has the lowest percentage (about 4 percent) of stands in the stand development stages that provide very large trees, including none in the fully functioning and old natural forest stages. Very large trees are scarce on DNR trust lands in most westside watersheds. In approximately one-third of the watersheds, less than 1 percent of the riparian area consists of very large trees. In nearly half (47 percent) of the watersheds, less than 5 percent of the riparian area consists of very large trees.

Approximately 21 percent of DNR riparian stands are in the ecosystem initiation and sapling exclusion stages, which include trees 0 to 9 inches in diameter at breast height. Nearly 30 percent of the riparian stands in the Olympic Experimental State Forest are in these early developmental stages. Summarization of the data for DNR-managed westside trust lands by watershed indicates that approximately 9 percent of the watersheds have riparian land class areas that are mostly in the ecosystem initiation and sapling exclusion stages, and approximately 35 percent of the watersheds have at least one-quarter of the riparian land class area in these early developmental stages. These levels suggest that a substantial amount of riparian areas were disturbed prior to the implementation of the Habitat Conservation Plan (DNR 1997).

In conclusion, the distribution of stand development stages within riparian areas suggests that many moderate to large streams on DNR westside trust lands may have reduced levels of one or more riparian functions because of low levels of large, fully functioning trees. These areas are likely to remain in this status for the near future because they contain moderate to high levels of early stand developmental stages. In contrast, many small to moderately sized streams may be approaching a moderate to high level of function from trees in intermediate developmental stages. Overall, riparian areas have a relatively high proportion of early and mid-developmental stages and low proportions of older developmental stages of forest.

Forest Management in Riparian Zones

The amount of activity in Riparian Management Zones was estimated in the Habitat Conservation Plan. Use of herbicides or fertilizers in riparian zones is uncommon on DNR westside trust lands. If herbicides or fertilizers are used, they are applied manually within riparian zones.

The effects on riparian functions of low-intensity timber management systems (such as single-tree selection and light small wood thinning) in Riparian Management Zones are not fully understood. Non-linear curves depicting the relationship between riparian function and distance from the stream [Washington Forest Practices Board 2001, pages 3-48, 49]) are generally based upon fully developed stands and suggest that most riparian functions are fully protected within one site potential tree height, a distance equal to the anticipated tree height for the specific site.

Removing trees within the Riparian Management Zone may temporarily reduce the level of certain riparian functions, but the extent of the reduction depends on where trees are



removed, the amount of trees removed, and the particular riparian function being considered (Washington Forest Practices Board 2001). Such near-term impacts would have to be evaluated against the potential to accelerate functional recovery.

Based upon recent evaluations of riparian function, a fully functioning stand that is 0.75 of a site potential tree height in width from a stream (approximately 105 feet for Douglas-fir on site class III soils) would provide complete shade protection and about 90 percent of large woody debris recruitment (Washington Forest Practices Board 2001).

Removal of some trees from this stand between 75 and 100 feet from the stream would likely reduce large woody debris recruitment, but would have minimal effect on shade. In addition, the conversion of hardwood areas (greater than 1 acre of contiguous hardwood) may result in a higher risk of blowdown in the no-harvest sub-zone. However, it is worth noting that many riparian stands are not fully functioning because of their current structural condition. Consequently, the degree to which low intensity timber management systems would affect near-term riparian function is uncertain. However, active forest management can change species composition and accelerate the development of larger trees. Such events help to restore longer-term riparian functioning but may have some short-term impacts.

In addition to causing loss of function through the removal of trees, management activities can disturb soils in the riparian zone. Yarding can result in compaction, rutting, and surface erosion if logs are not adequately suspended during yarding. Maintenance and re-growth of brushy vegetation and trees reduce the risk of adverse effects. Protection of stream bank integrity and adequate soil filtering of surface erosion are generally maintained with a fully functioning stand within 30 feet of a stream. Other than restoration activities, roads, and yarding corridors, none of the Alternatives proposes activities within the 25-foot no-harvest buffer along Types 1 through 4 streams for all westside planning units except the Olympic Experimental State Forest. Activities in the adjoining zones would be directed at achieving an old forest condition. Consequently, none of the Alternatives is likely to adversely affect stream bank stability or sediment filtering capacity from surface erosion. Although there is more flexibility for silvicultural prescriptions within riparian management zones for the Olympic Experimental State Forest relative to the other five planning units, bank stability and riparian conservation goals are important features to the Aquatic Conservation Strategy that is considered when silvicultural prescriptions are developed.

A riparian stand may not be fully functioning because of current conditions, previous management activities, disturbance from fluvial processes, disease, or fire. Carey et al. (1996) proposed that active management of forest stands on a biodiversity pathway using alternative silvicultural practices can result in full stand function being achieved more rapidly. These alternative practices may include:

- pre-commercial and modified commercial thinning to stimulate tree growth and understory development;



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- planting to supplement natural regeneration; and
- retention of large legacy trees.

4.3.4 Environmental Effects

Forest management activities, including road building and stream crossings, yarding corridors, restoration, vegetation management, fertilization and varying levels of timber harvest, will result in changes to the forest structure within the riparian areas.

Development of permanent roads removes trees along the road corridor, disturbs stream banks, and may provide a pathway for the transport of water and sediment from the roadway to a stream. Yarding corridors also remove trees, and may unacceptably contribute to soil disturbance or compaction along yarding corridors if adequate suspension of logs is not achieved, or appropriate mitigation measures are not implemented to reduce adverse effects. Yarding corridors are generally used when cross-stream yarding is more economical and less damaging to the environment than building a road.

The changes proposed to policies and procedures under the Alternatives are described in Chapter 2. Other policies and procedures that affect riparian conditions are described in Appendix C. Each Alternative proposes different levels of harvest activities in riparian areas (Table 4.3-2). During the remaining period of the Habitat Conservation Plan, Alternatives with lower levels of activity, such as Alternatives 1 and 4, are expected to have a higher proportion of riparian area with very large trees that are in competitive exclusion stages. In contrast, Alternatives with higher levels of active management, such as Alternative 6, are expected to have a lower proportion of riparian area with very large trees by the end of the Habitat Conservation Plan, but more riparian area will be fully functioning, or be on a trajectory towards full function. Regardless, riparian conditions are expected to improve under all Alternatives. This is due to changes in stand structure, particularly increases in the amount of stand development stages that include very large trees, which are in short supply throughout much of the DNR-managed westside trust lands (see Figure 4.3-2). The rate of improvement varies by Alternative. Active management is expected to achieve more fully functioning stands within 80 to 90 years, rather than approximately 220 years (Carey et al. 1996). Larger and taller trees in the riparian zone have a greater likelihood of providing streams with more functional large woody debris, more shade, more leaf and needle litter, and improved microclimate conditions.

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Table 4.3-2. Estimated Acres of Forest Management in the Riparian Land Class per Decade Among the Westside Planning Units Under Each Alternative

	Period	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Olympic	2004-2013	1,653	4,598	3,180	1,303	23,692	46,073
Experimental	2014-2023	1,830	5,561	2,825	1,234	29,033	62,566
State Forest	2024-2033	2,956	8,451	9,502	1,621	36,567	62,103
(110,000 total	2034-2043	2,787	10,512	10,722	1,689	29,467	80,279
acres in riparian	2044-2053	2,422	9,390	19,781	1,634	24,649	81,418
land class)	2054-2063	3,128	12,428	16,340	1,724	23,485	60,872
	2064-2067	1,361	4,086	9,653	810	9,742	18,260
	Mean	2,521	8,598	11,251	1,565	27,599	64,308
Five Westside	2004-2013	7,458	13,248	15,951	15,110	22,505	65,693
Planning Units	2014-2023	9,219	15,126	21,982	13,908	25,445	54,097
(excludes OESF;	2024-2033	11,989	20,109	21,779	16,845	33,571	94,253
315,000 total	2034-2043	10,779	20,911	25,759	18,848	27,370	77,953
acres in riparian	2044-2053	10,432	22,104	31,209	20,483	33,485	119,478
land class)	2054-2063	11,421	25,740	24,097	24,462	30,557	94,130
	2064-2067	3,836	7,772	8,932	9,430	10,474	49,346
	Mean	10,177	19,533	23,392	18,607	28,657	86,711

Data Source: Model output data – timber flow levels

OESF = Olympic Experimental State Forest

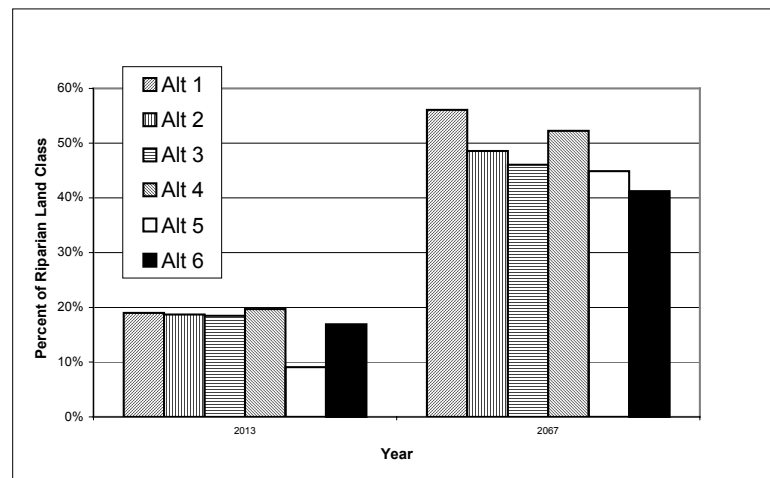


Figure 4.3-2. Percent of the Riparian Land Class that is in Very Large Tree Stand Development Stages (Botanically Diverse, Niche Diversification, Fully Functional, and Old Natural Forest) in the Short Term and Long Term

Note: Current conditions are estimated to be approximately 12% of 426,000 acres.

Source: DNR model output data



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Although Alternative 6 would be expected to result in the lowest amount of area with very large trees, this Alternative would likely result in a slightly higher amount (11 percent) of riparian land class area in fully functional or old natural forest stand development stages compared to the other Alternatives. Alternative 3 would be expected to result in the lowest amount (approximately 7 percent) (Figure 4.3-3). Alternative 1, which would likely result in the highest area of very large trees (approximately 56 percent of the riparian land class), would be expected to result in about 9 percent of riparian land class area in fully functioning or old natural forest stand development stages. The major added feature that distinguishes the fully functional and old natural forest stand development stages from other stages with very large trees is the presence of high levels of decadence, such as snags, down coarse woody debris, and epiphytes. Consequently, over the long term, the more-intensive biodiversity pathways approach proposed in Alternative 6 would likely yield slightly higher riparian function on more of the riparian land class than Alternative 1, but with the trade-off of having potentially less area with very large trees in the riparian land class. Given stand densities within the riparian areas, Alternative 1 may take a very long time to produce very large trees. Similarly, the heavier thinning proposed under Alternative 5 would be expected to produce higher riparian function on slightly more of the riparian land class than Alternative 1, but with less area supporting very large trees. If no future disturbance occurs to areas with very large trees, these stands would likely achieve full function over time.

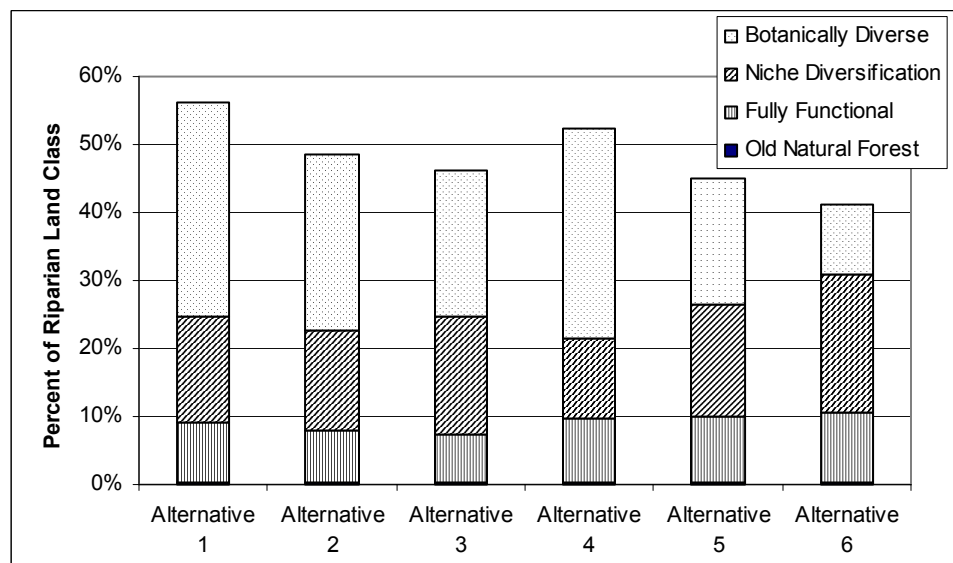


Figure 4.3-3. Estimated Percent of the Riparian Land Class Consisting of Various Stand Development Stages Including Very large Trees over the Long Term (2067) among the Alternatives

Source: DNR Alternative model output data



For most planning units during most decades under Alternative 6, the bulk of harvest activities consist of low-volume removals. In the Olympic Experimental State Forest, approximately 95 percent of the harvest activity is low volume removals. The Olympic Experimental State Forest management strategies are designed to accelerate restoration efforts in close, dense stands that dominate the current conditions of the forest landscape. In the Olympic Experimental State Forest, harvest can currently occur in interior-core buffers, provided that management activities are consistent with conservation objectives. The Olympic Experimental State Forest riparian strategy also allows light partial harvests and relies on experiments for harvesting in the exterior buffer of up to 33 percent of the available volume (DNR 1997, page IV.134).

Large woody debris recruitment, leaf and needle litter production, and shade conditions would be expected to improve under all Alternatives. However, relative to Alternative 1, some short-term reduction in leaf and needle litter production and long-term reduction in shade and large woody debris may occur from the removal of riparian trees. Generally, this impact would be expected to be relatively minor except under Alternative 6, and in the Olympic Experimental State Forest under Alternative 5. Under Alternative 6, reductions in leaf and needle litter, shade, and large woody debris recruitment potential could occur in some planning units during some decades. This would likely occur because the level of disturbance to the riparian land class could be as high as 73 percent of the area during the 2044 to 2053 time period in the Olympic Experimental State Forest, whereas the level of disturbance is commonly 30 percent or greater during other decades and in other westside planning units (Appendix D.3). However, these levels of disturbance from harvest activities are the results of low volume removals or thinnings in close, dense stands in the competitive exclusion phases. These effects would likely be more pronounced in areas where tree removal occurs in the no-harvest and minimal harvest sub-zones.

Activities in the riparian zone under Alternative 6 using ground-based and cable yarding methods could result in low to moderate levels of soil compaction and/or rutting and surface erosion along skid trails, but on a more frequent basis. Under Alternative 5, the Olympic Experimental State Forest would likely experience disturbance levels as high as 33 percent in a decade and over 20 percent for other decades. The highest level of disturbance for planning units during a decade is expected to be about 18 percent or less under all other Alternatives and is usually less than 10 percent (Appendix D.3).

None of the Alternatives proposes activities within the 25-foot no-harvest buffer along Types 1 through 4 streams, except for yarding corridors, roads, and restoration activities. Consequently, none of the Alternatives is likely to cause substantial adverse effects on stream bank stability or sediment filtering capacity from surface erosion.

The relative impact to riparian microclimate among the Alternatives is uncertain. Riparian microclimate conditions would likely improve under all Alternatives as the amount of area in stand development stages with small trees declines with time and the amount of area in developmental stages with very large trees increases. The effects of patch cuts, small openings, and thinnings on riparian microclimate are largely unknown. If differences were to occur among the Alternatives, the level and type of riparian disturbance would be the



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best relative indicator available, with Alternative 6 having the highest likelihood of expressing any difference and Alternatives 1 and 4 having the lowest.

Alternatives 5 and 6 would have the highest likelihood of affecting riparian microclimate, based on the projected relatively high level of harvest activities. However, the majority of these activities are low volume removals, most probably thinnings, and these activities are necessary to produce the increase in the amount of more “fully functional” forests in the riparian zone. The actual nature of these harvest operations, whether they are ground or cable, the type of equipment use, etc., and how they interact with site-specific factors, are beyond the scope of this analysis. The analysis of these interactions will be performed at the project level.

Harvest prescriptions and mitigation measures including avoidance, short-term deferral, harvest and yarding method, restoration, or other measures can be implemented in Riparian Management Zones. The details will be analyzed at the project level. Mitigation in the form of more intensive monitoring would be necessary for Alternatives 5 and 6, which have relatively higher levels of forest management activity in riparian zones. Monitoring of harvest operations is necessary to assess the level of impact in future operations and to ensure the thinnings result in the benefits of accelerated forest development.



4.4 WILDLIFE

4.4.1 Summary of Effects

This section analyzes the environmental effects on wildlife resources and examines the effects of prospective changes to current policy and procedures. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

All Alternatives are consistent with the goals and objectives of the Habitat Conservation Plan. Environmental effects anticipated under all six Alternatives would be within the level of impacts anticipated to wildlife species and analyzed in the Habitat Conservation Plan Environmental Impact Statement (DNR 1996). Changes in management of northern spotted owl habitat under some Alternatives would be consistent with the goals and objectives of the Habitat Conservation Plan.

Other policy and procedure changes under the Alternatives would influence the amount and distribution of wildlife habitat on DNR westside trust lands. The Alternatives would vary in the timing and amount of forest structures they would create, but would not be expected to have any significant adverse environmental effects on wildlife beyond existing conditions and those anticipated in the Habitat Conservation Plan Environmental Impact Statement. In both the short term and long term, the amount of structurally complex forest is modeled as increasing in all planning units under all Alternatives. Structurally complex forest cannot be used as a measure of DNR's success in meeting its obligations under the Habitat Conservation Plan. Instead, structurally complex forests serve as a relative indicator of change in the amount of habitats of management concern under the Alternatives.

4.4.2 Introduction

This section identifies the potential effects of each forest management Alternative regarding proposed changes to policies and procedures on wildlife species and their habitats. Included is how these effects may differ among the six Alternatives. Appendix C provides an overview of the policies and procedures that govern DNR's management of wildlife resources, as well as those that influence the quality, quantity, and distribution of various wildlife habitats on the forest landscape. Affected Environment discusses wildlife habitats and species of special interest that are affected by current forest management. Finally, this section describes how procedural changes under the proposed Alternatives would affect wildlife habitats and populations.

Wildlife-related issues raised during internal DNR and public scoping processes include:

- the availability and distribution of northern spotted owl habitat over time (and forest structure in general). The status of the northern spotted owl population in southwestern Washington was highlighted as a matter of particular concern;
- the protection of currently suitable habitat for species such as the marbled murrelet;
- the maintenance of habitat features that contribute to biological diversity (e.g., snags, logs, canopy gaps); and



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- the potential for harvest levels to be affected by conservation measures for uncommon habitats.

4.4.3 Affected Environment

4.4.3.1 Habitats

This section describes five general types of wildlife habitat that occur on DNR-managed westside trust lands, gives examples of species associated with these habitats, and describes their distribution among management zones.

The five wildlife habitat types addressed in this analysis are:

- ecosystem initiation forest,
- competitive exclusion forest,
- structurally complex forest,
- riparian and wetland habitats, and
- uncommon habitats.

The first three habitat types consist of groupings of forest structure classes, which are a way of classifying forest stands according to various levels of structural and vegetative complexity (Johnson and O'Neil 2001). Forest structure classes are described at greater length (related to the stand development stages described by Carey et al. [1996]) in Section B.2.1.2, Appendix B. Table 4.2-4 provides the current distribution of stand development stages on westside trust lands. The total acreage of these habitat types by planning unit is summarized in Table 4.4-1.

Table 4.4-1. Acres of Wildlife Habitat Types Among Westside Trust Lands by Habitat Conservation Planning Unit

Habitat Type	Planning Unit						Total
	Columbia	N. Puget	OESF ^{5/}	S. Coast	S. Puget	Straits	
Ecosystem Initiation Forest	23,390	32,211	15,657	20,636	12,130	10,528	114,552
Competitive Exclusion Forest ^{1/}	216,207	316,573	196,216	187,381	119,167	95,011	1,130,555
Structurally Complex Forest ^{2/}	27,934	32,731	44,786	24,915	10,547	4,682	145,595
Other Lands (including many uncommon habitats) ^{3/}	26,124	51,892	13,872	23,544	16,527	7,083	139,042
Riparian Areas and Wetlands ^{4/}	80,163	83,355	65,310	79,224	31,204	18,299	357,555

Data Source: Model output data – stand development stages

1/ Includes sapling exclusion, pole exclusion, and large tree exclusion stages

2/ Includes understory reinitiation, developed understory, botanically diverse, niche diversification, fully functional, and old natural forest stages. Includes approximate acres of old natural forest, defined as unmanaged stands greater than 250 years old, as well as those meeting the criteria of the fully functional stand development stage.

3/ Includes road rights-of-way, lakes and rivers, non-inventoried lands, and non-forested lands (e.g., grasslands, agricultural areas, utility easements, developed lands, beaches, bare rock, snow, and ice).

4/ Riparian areas are defined by buffers around streams, and wetlands include forested and non-forested wetland types. As such, both riparian areas and wetlands overlap other habitat types (including each other) and are not included in total area calculations. See Section 4.9.1.3 for a discussion of how wetlands were identified for this analysis.

5/ OESF = Olympic Experimental State Forest



Ecosystem Initiation Forests

Ecosystem initiation forests represent the initial phases of forest development following a major disturbance such as a fire or regeneration harvest. They correspond to the grass/forb and shrub/sapling forest structure classes. Young forest stands with an open canopy and plentiful shrub cover support a diverse assemblage of birds—bird species diversity and overall abundance is highest in stands in the ecosystem initiation stage (Carey et al. 1996). Such stands also provide abundant forage for wide-ranging ungulate species (deer and elk). Other species closely associated with forests in the ecosystem initiation stage include the white-tailed ptarmigan, yellow-breasted chat, and Townsend's vole (Johnson and O'Neil 2001). Structural legacies (e.g., large snags and down logs) retained from the previous stand can increase biological diversity by providing habitat for small mammals, cavity-nesting birds, and terrestrial amphibians (Carey et al. 1996). In managed landscapes, retention of such legacies combined with a management program designed to promote biological diversity may speed the development of more-complex forest ecosystems (Carey and Curtis 1996, Carey et al. 1996, Carey 1998).

Currently, about 8 percent of westside forested trust lands consist of ecosystem initiation forest (Table 4.4-1); about 42 percent of this occurs in upland areas with general management objectives.

Competitive Exclusion Forests

Forests of the competitive exclusion stages generally have a single, dense canopy layer dominated by trees between 10 and 30 inches in diameter at breast height. Small snags and down logs are often present, the result of suppression mortality as trees compete for available resources. Large decaying logs and stumps may be present as remnants of previous disturbances, such as windstorms or harvests. Forest structure classes that make up this habitat type include the closed-canopy shrub/sapling class, pole-sized classes, and all large-tree classes described by Johnson and O'Neil (2001), except for multistoried large-tree stands with less than 70 percent canopy cover (Appendix Table B-2).

In younger competitive exclusion stands, the high density and uniform size of relatively short trees allows only small amounts of sunlight to reach the forest floor, creating sparse understory conditions and low levels of biological diversity. Canopy gaps—either as a result of thinning or natural mortality—allow understory plants to become established. The result is a gradual increase in biological diversity. The competitive exclusion stages have the lowest biodiversity and the least favorable conditions for wildlife when compared to all the forest stages described by Carey et al. (1996). No wildlife species in western Washington are found exclusively in competitive-exclusion forests (Carey and Curtis 1996).

Competitive exclusion forests are the most common forest habitat type on DNR-managed westside trust lands, making up 81 percent of the total forested area (Table 4.4-1). Approximately 26 percent of this habitat type occurs in upland areas with general management objectives.



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Structurally Complex Forests

Structurally complex forests typically feature multiple canopy layers, with the top layer dominated by trees greater than 30 inches in diameter at breast height. Forest structure classes that make up this habitat type include multistoried large-tree stands with less than 70 percent canopy cover, and all stands dominated by trees greater than 30 inches diameter at breast height. In the more fully developed stages, snags and down logs play a vital role in providing structural and biological diversity (Section B.2.1.2, Appendix B). Forested stands meeting the criteria of the fully functional stage (Carey et al. 1996), along with those with a stand age greater than 250 years and no history of silvicultural activity, are identified in this analysis as “old forest.”

Biological diversity in this forest habitat type is promoted by structural complexity along both the vertical axis (i.e., trees of different heights, as well as shrubs and herbaceous plants) and the horizontal axis (e.g., gaps in the forest canopy) (Carey et al. 1996, Franklin et al. 2002). A diversity of plant species and growth forms in structurally complex forest provides niches for a wide variety of wildlife species. For example, structurally complex forests have an understory of small trees, shrubs, ferns, and herbs, providing foraging opportunities for herbivores and breeding habitat for ground-nesting birds (Carey et al. 1996). Large snags and down logs in the more fully developed stages of this class (or in other stages, if present as legacies) may provide suitable habitat conditions for a variety of important species, including nest sites for spotted owls, roost sites for bats, and den sites for Pacific fishers. Very large trees may also provide nest sites for other wildlife species, including bald eagles and marbled murrelets.

Structurally complex forest makes up about 10 percent of the total forested area on DNR-managed westside trust lands (Table 4.4-1). Among the planning units, the Olympic Experimental State Forest supports the highest proportion (17 percent) and the Straits Planning Unit supports the lowest (4 percent) of this forest habitat type. Currently, about 18 percent of the structurally complex forest on westside trust lands occurs in areas with general management objectives; the other 82 percent occur in riparian and wetland areas or uplands with specific management objectives (including the entire Olympic Experimental State Forest). Old forest makes up less than 6 percent of the structurally complex forest in westside trust lands.

Riparian and Wetland Habitats

Water plays a significant role in the development of landforms and vegetation in riparian and wetland areas, which are defined more fully in Sections 4.3 and 4.9, respectively. Riparian habitats range from headwater streams and seeps to broad, flat river valleys. Wetlands include both forested and non-forested types. Numerous wildlife species use riparian and wetland habitats to fulfill all or portions of their life requisites such as breeding, foraging, resting, and traveling from one geographical area to another. Examples of species associated with these habitat types include beaver, mink, river otter, waterfowl, herons, and most amphibian species. In addition, several threatened, endangered, and sensitive species depend on riparian and wetland habitats for some or all of their life



requisites (see Appendix Table D-7). Riparian and wetland habitats occur throughout all the westside planning units, encompassing about 23 percent of the DNR-managed westside trust lands.

Uncommon and Non-forest Habitats

While the great majority of DNR-managed westside trust lands supports forests of various structural classes, non-forested habitats also play a significant role in providing the life requisites of many wildlife species. Cliffs and talus, for example, provide habitat for species such as peregrine falcons, pikas, mountain goats, and Larch Mountain salamanders. Native grasslands serve as breeding and foraging areas for numerous bird and mammal species, and support host plants for certain rare butterfly species. Oak woodlands, while technically classified as forestlands, warrant specific consideration in the DNR Habitat Conservation Plan due to the rarity of this habitat type and its role in supporting some uncommon wildlife species such as the Lewis' woodpecker and western gray squirrel. Available data distinguish between forested and non-forested areas, but do not identify individual non-forested habitat types on DNR-managed forestlands. "Other Lands" identified in Table 4.4-1 include such non-forested land cover types as grasslands, agricultural areas, utility easements, developed lands, beaches, bare rock, snow, and ice. Also included in the total acreage of "Other Lands" are road rights-of-way (58,000 acres total), lakes and rivers (9,000 acres total), and recently acquired lands that have not yet been inventoried.

4.4.3.2 Species of Interest

Most species of interest in this Environmental Impact Statement are those with a regulatory status that indicates particular concern for their viability on DNR-managed westside trust lands, such as species classified as threatened, endangered, or sensitive under Washington Administrative Code 232-12-297.

The northern spotted owl and marbled murrelet receive particular attention due to their listing status under the federal Endangered Species Act, their close association with structurally complex forest, and their occurrence on westside state trust lands. Other species of management interest are deer and elk, which are game species of cultural significance to Tribal and other hunters, and are also valuable prey species for wolves and other large predators. Salmonids are addressed in Section 4.10 (Fish). The 1997 Habitat Conservation Plan and associated Environmental Impact Statement are the primary sources of information about species addressed in this section. Where changes have occurred in the regulatory status of an individual species, or in the understanding of its habitat associations, information is updated accordingly in the subsections below.

Northern Spotted Owl

Throughout much of their range, northern spotted owls are strongly associated with forested areas that are classified as structurally complex in this Environmental Impact Statement as discussed above. Spotted owl habitat requirements are addressed in DNR's Habitat Conservation Plan through the provision of nesting, roosting, and foraging



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management areas and in dispersal management areas. Nesting, roosting, and foraging habitat corresponds roughly with forested areas that are classified as structurally complex. Dispersal habitat is likely met in closed-canopy stands in the pole and large tree size classes (Appendix Table B-2), in addition to the stages that make up structurally complex forest.

Notably, the forest structure classes analyzed in this document are defined using a different set of criteria than the habitat definitions described in the Habitat Conservation Plan. Structurally complex forest is not quite the equivalent of nesting, roosting, and foraging habitat; therefore, neither the summaries of current conditions nor the modeled projections of future conditions should be used as a measure of DNR's success in meeting its obligations established under the plan. The two habitat types are similar enough, however, that for this analysis, structurally complex forest can serve as an index to the relative changes in the amounts of nesting, roosting, and foraging habitat over time under the proposed Alternatives.

DNR Procedure 14-004-120, Management Activities Within Spotted Owl Nest Patches, Circles, Designated Nesting, Roosting, and Foraging and Dispersal Management Areas, was designed as a short-term measure to allow DNR to continue to support the current population of owls by maintaining key habitat around certain known owl sites, while new habitat develops in long-term designated areas. Currently, 28 "Memorandum 1" owl circles are identified as overlapping forested state trust lands in western Washington, along with 78 Status 1-Reproductive and 4 Southwestern Washington owl circles. Timber harvest within the non-habitat portions of these circles is deferred until nesting habitat has been identified. To date, only one HCP Planning Unit has met this habitat identification requirement, with the net effect that timber harvest is not allowed throughout most of these circles.

As noted in Table 4.4-1, structurally complex forest (used here as an estimate of nesting, roosting, and foraging habitat) accounts for about 10 percent of forested areas of westside forested trust lands. The proportion is slightly higher (11 percent) within areas specifically designated for nesting, roosting, and foraging management.

When the Habitat Conservation Plan was completed in 1997, several studies had described northern spotted owl populations declining in many parts of their range, but the magnitude of these declines was a matter of much debate (Anderson and Burnham 1992, Thomas et al. 1993, Burnham et al. 1994, Bart 1995). Additional research and analysis since that time has provided further evidence that spotted owl populations are continuing to decline. Analysis by Franklin et al. (1999) suggested that the population on the Olympic Peninsula was declining at a rate of about 6 percent per year. Further study by Forsman and Biswell (2003) did not suggest any improvement. Forsman and Biswell (2003) offer three possible explanatory factors behind the continued population decline: (1) loss of habitat, (2) the invasion of the Olympic Peninsula by the barred owl, and (3) high mortality resulting from the severe winter of 1998-1999.



Marbled Murrelet

Reflecting the lack of certainty about the specific habitat needs of marbled murrelets, the Habitat Conservation Plan defined an interim conservation strategy for this species. The interim strategy for marbled murrelets involves habitat relationship studies designed to identify marginal habitats that have the greatest potential to support murrelets. These studies have not been completed in all six westside planning units; therefore, analyses in this Environmental Impact Statement take a more general approach, using structurally complex forest as an indicator for suitable nesting habitat for marbled murrelets.

Analyses conducted for DNR's Habitat Conservation Plan Environmental Impact Statement (DNR 1996) indicate that most forest stands greater than 110 years of age have sufficient numbers of nesting platforms to support murrelets. Model output data for 2004 show that most forests classified as structurally complex are at least 90 years old, so there is likely considerable overlap between structurally complex forest and murrelet nesting habitat.

The Marbled Murrelet Recovery Plan (USFWS 1997) identifies terrestrial (upland) habitat essential for marbled murrelet recovery. The Recovery Plan identifies additional areas on non-federal land where existing habitat should be protected because habitat in federal reserves is insufficient to reverse population declines and maintain a well distributed population. In the state of Washington, such additional essential habitat occurs on state lands within 40 miles of marine waters. These areas are critical for improving the distribution of the population and suitable habitat, especially in southwestern Washington (USFWS 1997). Effects on forestlands within 40 miles of marine waters, therefore, are of particular concern in determining the effects of the Alternatives on marbled murrelet populations.

Of the approximately 145,600 acres of structurally complex forest on westside trust lands (Table 4.4-1), approximately 85 percent occur within 40 miles of marine waters, and an additional 4 percent occur between 40 and 50 miles from marine waters.

Other Threatened, Endangered, and Sensitive Species

Appendix Table D-7 lists the threatened, endangered, and sensitive species that are known or suspected to occur on DNR-managed westside trust lands. This table identifies each species' state and federal listing status, and the habitats with which it is associated.

DNR procedures provide specific direction for the management of habitat for species of interest, including threatened, endangered, and sensitive species (see Appendix C).

Deer and Elk

As noted above, black-tailed deer and Roosevelt elk are game species of cultural significance to Tribal and other hunters, and are also valuable prey species for wolves and other large predators. As large and mobile animals, deer and elk can use different habitat elements in different forest types. Open habitats (e.g., ecosystem initiation forest) often provide foraging opportunities for these species. Studies in northwestern Washington have found that elk use thinned stands more than clearcuts for foraging. In contrast, closed-



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canopy forest may provide seclusion from human harassment (Cook et al. 1998). Both forage areas and cover can be provided by structurally complex forests. Understory vegetation provides forage while older trees in the overstory provide substrates for lichen production, decrease on-the-ground snow accumulation, and are a source of cover (Carey et al. 1996).

Habitat suitability models for deer and elk in western Washington and Oregon consider many factors, including quality of cover habitat, size and spacing of forage and cover areas, and road density (Witmer and deCalesta 1985, Wisdom et al. 1986). While an assessment of impacts to all the factors that contribute to habitat effectiveness for deer and elk is beyond the scope of this programmatic assessment, it is possible to indirectly address one key factor—size and spacing of forage and cover—by examining the proportion of forage habitat on the landscape.

Several studies of deer and elk have noted a decreased use of forage habitat when it is farther away from cover (Wisdom et al. 1986). As the proportion of forage habitat in a given area increases above 50 percent, the amount of forage in proximity to effective cover habitat will by necessity decrease. On the other hand, inadequate forage also reduces the capability of an area to support deer and elk. In areas managed for timber production, the Washington State Department of Fish and Wildlife has recommended that 30 to 60 percent of the landscape should consist of forage habitat (Washington State Department of Fish and Wildlife 1996). Data available for this analysis can be analyzed at three scales: all DNR-managed westside state trust lands, the six planning units, and watersheds. Of these, watersheds provide a suitable landscape scale for DNR to analyze foraging habitat, because they come closest to matching the area over which deer and elk may range during a season (e.g., Jenkins and Starkey 1990).

For this analysis, watersheds in which 30 to 60 percent of the forested area consists of structurally complex, ecosystem initiation, or open-canopy pole- or large-tree forest, are considered to provide suitable habitat for deer and elk. Currently, there are 124 watersheds in which foraging habitat makes up 30 to 60 percent of DNR-managed forests (Table 4.4-2). This amounts to 38 percent of the 324 westside trust land watersheds.

4.4.4 Environmental Effects

Changes to policies, procedures, and management intensities proposed in the Alternatives would be expected to affect wildlife species and the habitats with which they are associated. Effects of proposed changes in the policies and procedures that govern timber harvest and the protection of riparian and wetland areas are described in Sections 4.2, 4.3, and 4.9, respectively. The subsections below describe the potential effects on wildlife anticipated from the revisions to DNR policies and procedures, and from changes in harvest levels proposed in the Alternatives.

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Table 4.4-2. Number of Watersheds^{1/} Supporting Percentages of Deer and Elk Foraging Habitat Among Westside Planning Units

Percentage of Foraging Habitat	Number of Watersheds						Total
	Columbia	N. Puget	OESF ^{2/}	S. Coast	S. Puget	Straits	
≤30% Forage	26	62	22	21	20	12	163
30%-60% Forage	35	28	8	21	17	15	124
>60% Forage	5	10	1	12	9	0	37
Total	66	100	31	54	46	27	324
<i>Percent in 30%-60% range</i>	<i>53%</i>	<i>28%</i>	<i>26%</i>	<i>39%</i>	<i>37%</i>	<i>56%</i>	<i>38%</i>

Data Source: Model output data – stand development stages

^{1/} The term “watershed” is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

^{2/} OESF = Olympic Experimental State Forest

The Forest Resource Plan and the Habitat Conservation Plan establish the goals and objectives for management of DNR lands. The proposed Alternatives represent various means of achieving these ends. Based on the extent and type of timber harvest proposed under the Alternatives, some Alternatives may achieve the desired goals sooner or later than others.

Model output results were used to estimate variations in sustainable forest management practices under the six Alternatives. Results show one of many pathways by which DNR might meet sustainable forest management objectives that include full regulatory compliance and providing the important conservation benefits specified by the Habitat Conservation Plan.

4.4.4.1 Habitats

This section addresses changes in the amount or quality of the five general wildlife habitat types under each Alternative, and how such changes may affect wildlife species associated with these habitats. Changes in the relative amount of forested habitat types are a product of varying rates and intensities of timber harvest under the different Alternatives.

Appendix Table D-8 presents the modeled proportion of westside forested trust lands comprising ecosystem initiation, competitive exclusion, and structurally complex forests under each Alternative in the years 2013 (short-term) and 2067 (long-term).

The acreage and location of riparian and wetland areas and uncommon habitats are not expected to change under any of the Alternatives, but the quality of the habitat provided by these areas would be expected to vary as a result of different amounts of harvest activity and intensity.

Ecosystem Initiation Forest Habitat

In a managed forest landscape, the amount of ecosystem initiation forest habitat depends primarily on the amount and intensity of regeneration harvest activity. Alternatives with higher levels of regeneration harvest would produce greater amounts of ecosystem



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initiation forest. Conversely, Alternatives with lower acreages of regeneration harvest would result in less of this habitat type, as less area would be harvested in any given time period.

This trend is evident in the model output for the six Alternatives. In both the short term and the long term, the amount of ecosystem initiation forest expected under Alternative 1 (No Action), and Alternative 4 would remain slightly below the levels expected under the other Alternatives (Figure 4.4-1, Appendix Table D-8). In both the short term and the long term, the greatest amount of this habitat type would occur under Alternative 5, under which the greatest amount of high-intensity harvest would be expected to occur.

Overall, all six Alternatives would result in similar amounts of ecosystem initiation forest in both time frames, and no significant difference would be expected among the effects of the Alternatives on wildlife species associated with this forest type. This may not hold true within certain planning units in some time periods. For example, model results for Alternative 3 suggest that 28 percent of the Straits Planning Unit would consist of this habitat type in 2013, more than double the proportion in DNR-managed westside trust land as a whole. Alternatives 5 and 6 results also predict that more than 20 percent of the Straits Planning Unit would consist of ecosystem initiation forest.

No strict thresholds have been identified for an acceptable amount of ecosystem initiation forest habitat in a given landscape. However, elevated amounts of this habitat type indicate an increased potential risk of habitat fragmentation among closed-canopy forest types (e.g., structurally complex).

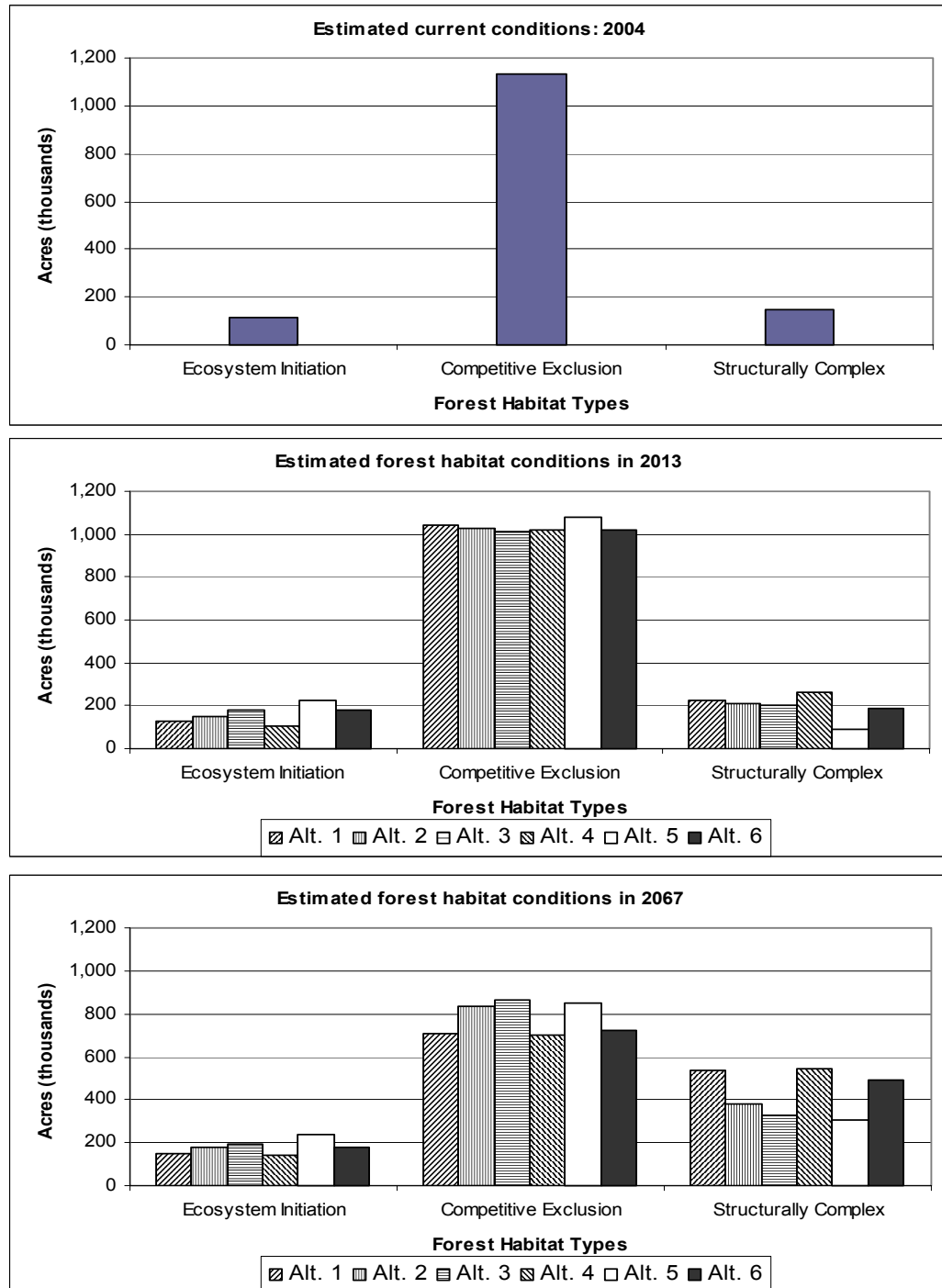
Carey et al. (1996) note that some forest bird species reach their greatest abundance and diversity in forest stages with high shrub cover, particularly ecosystem initiation forest. Long-term increases in the amount of ecosystem initiation forest on the landscape would likely result in localized increases in populations of these species. This would occur with corresponding decreases in the amount of competitive exclusion forest, which is characterized by low abundance and diversity among these species. Deer and elk would also be expected to benefit from the increased availability of foraging habitat in proximity to competitive exclusion and structurally complex forest (both of which provide cover).

Competitive Exclusion Stages

Forest in the competitive exclusion stages is currently the most abundant habitat type on DNR-managed westside trust lands. Under all Alternatives, the majority of timber harvest is expected to occur in this habitat type. The amount of competitive exclusion forest would likely be affected by two processes: conversion to ecosystem initiation forest through high-volume timber harvest, and development into structurally complex forest through natural forest succession, as well as forest management activities such as thinning.

Model output data indicate that the amount of competitive exclusion forest on westside trust lands would decline under all six Alternatives in both the short term and the long term (Figure 4.4-1). In the short term, results show very little difference in the amount of

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Source: Model output data – stand development stages

Figure 4.4-1. Current (2004) and Estimated Future Amounts of Forested Habitat Types on DNR-managed Westside Trust Lands Under Each Alternative



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competitive exclusion forest among the Alternatives (Appendix Table D-8). At the end of the planning period, by 2067, the Alternatives separate into two groups: under Alternatives 1, 4, and 6, approximately 50 percent of westside trust lands would consist of competitive exclusion forest, while Alternatives 2, 3, and 5 would have about 60 percent.

For the most part, decreases in the amount of competitive exclusion forest correspond to increases in the amount of structurally complex forest. This result suggests that many areas that currently sustain competitive exclusion forest would acquire the characteristics of structurally complex forest over time. The greatest long-term declines in competitive exclusion forest would likely occur under Alternatives 4, 1, and 6, followed in descending order by Alternatives 2, 5, and 3.

The change in these closed-canopy competitive exclusion forest stands into more diverse, structurally complex forests would occur only as the canopy opens up. The tree canopy of a forest stand opens as a tall tree or some smaller trees die, or as a tree gets taller and allows sunlight to reach the forest floor below its high branches. Trees in the canopy and sub-canopy die for a number of reasons. The principal reasons include lack of food and light resources due to competition among trees, and natural disturbances such as wind, fire, insects, and disease.

Declines in the amount of competitive exclusion forest would not be expected to result in any significant adverse effects to wildlife species overall. No wildlife species are found exclusively in competitive exclusion forests, and decreases in the amount of competitive exclusion forest would nearly be matched by increases in structurally complex forest. Additionally, retrospective studies of vertebrate communities in intensively managed commercial forests (e.g., Aubry et al. 1997) and natural forests (e.g., Ruggiero et al. 1991) show broadly similar species lists. Thus, no wildlife species would be expected to experience habitat reductions, and overall wildlife diversity may increase with the increased amounts of forest habitat types (ecosystem initiation and structurally complex) that generally support greater abundance and diversity of wildlife species (Carey et al. 1996).

Structurally Complex Forest

In the short term, changes in the amount of structurally complex forest under the six Alternatives would largely be the result of different levels of management intensity. Alternatives with more high-volume timber harvests (i.e., Alternatives 5 and 6) would be expected to result in less of this habitat type than those with more areas deferred from harvest (Alternative 1), or those with older minimum-average-regeneration-harvest age (Alternative 4). Under the latter two Alternatives, in any given time period, fewer structurally complex stands would be subject to heavy thinning or regeneration harvest; these Alternatives, therefore, would show greater acreage of complex forest relative to an Alternative that emphasizes intensive management. In the long term, the amount of structurally complex forest would also depend on the forests' growth and development, which would in turn be influenced by their harvest history. For example, competitive exclusion stands that have been thinned can be expected to acquire the characteristics of



structurally complex forest sooner than those that are left alone (Carey et al. 1996, Thysell and Carey 2000).

Model output supports this expectation. In both the short term and the long term, Alternatives 1 and 4 result in the greatest amount of structurally complex forest on westside trust lands (Figure 4.4-1). All other Alternatives also result in net increases in both the short term and the long term, but to a lesser degree. Alternative 5 exhibits the smallest increases in both time periods. Model results suggest that Alternative 6 would yield a moderate increase in structurally complex forest in the short term, and nearly as much as Alternatives 1 and 4 in the long term.

For the most part, this overall pattern is repeated at the individual planning unit scale. The main exception is the South Puget Planning Unit, where among the proposed Alternatives, Alternative 6 appears to yield some of the greatest increases in structurally complex forest in the long term. Alternative 6 also proposes the most acres of timber harvest in the South Puget Planning Unit, as well as the greatest decline in competitive exclusion forest.

These findings suggest that biodiversity pathways management appears to be compatible with the goal of maximizing the amount of structurally complex forest, at least in some areas. Alternative 5 proposes more traditional heavy thinning prescriptions and appears to yield the second-highest harvest levels in the South Puget Planning Unit. However, it appears Alternative 5 would result in the smallest increases in structurally complex forest in this unit in almost all time periods. For a discussion of changes in the amount of structurally complex forest in the Olympic Experimental State Forest under the six Alternatives, see the analysis of northern spotted owl nesting, roosting, and foraging habitat availability in Section 4.4.4.2 below.

While passive management appears to result in the greatest increases in structurally complex forest as a whole, active management, including more intensive management using biodiversity pathways techniques, appears to result in greater long-term increases in forest structure classes characterized by the highest amounts of snags and logs.

Alternative 6 would result in the third-highest long-term net increase in the amount of structurally complex forest overall, after Alternatives 1 and 4. However, an examination of the three stand development stages that are characterized by abundant woody debris (niche diversification, fully functional, and old forest), puts Alternative 6 ahead of Alternative 1 with the second-highest long-term net increase. If the modeling of “structure” is accurate—and if the resources are available to implement this level of management intensity—then the biodiversity pathway techniques employed by Alternative 6 may provide improvements in forest diversity comparable to a more “hands-off” approach, while increasing timber flow from trust lands (see Figure 4.2-2).

Riparian and Wetland Habitats

Effects to species associated with riparian habitats under the different Alternatives would result from timber harvest activities in Riparian Management Zones and from changes in riparian habitat conditions. Increased levels of harvest activity in the riparian areas increase the potential for disturbing wildlife species that use these areas, and of altering



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habitat features upon which they depend. Active management can also accelerate the rate at which a stand reaches structurally complex forest stages. Short-term impacts are to be considered with the understanding of long-term benefits. Over time, development of structurally complex forest dominated by large trees improves the ability of riparian areas to play a vital role in the health of stream ecosystems and terrestrial ecosystems.

Section 4.3, Riparian Areas, presents the effects of forest management activities on riparian areas under the six Alternatives. The greatest amount of timber harvest activity in the riparian areas (and thus the greatest potential for adverse effects to riparian-associated wildlife species) is modeled as occurring under Alternative 6, followed in descending order by Alternatives 5, 3, 2, 4, and 1. Under current conditions, structurally complex forest is relatively scarce in riparian areas throughout westside state trust lands. Under all Alternatives, model results suggest a gradual improvement, because the amount of structurally complex forest would increase under all Alternatives. During the remaining period of the Habitat Conservation Plan, Alternatives with lower levels of activity, such as Alternatives 1 and 4, are expected to have a higher proportion of riparian area in forest with very large trees. The majority of the riparian forest with very large trees, however, is modeled as being in the botanically diverse stage (Figure 4.3-3), which is characterized by limited biotic diversity overall (Section B.2.1.2, Appendix B). In contrast, the majority of riparian forest with very large trees under Alternative 6 would consist of the niche diversification, fully functional, and old-growth stages, which are characterized by greater levels of structural and biotic diversity. Thus, although Alternative 6 would be expected to result in the smallest long-term increases in the amount of structurally complex forest in riparian areas, it would result in the greatest increases in the forest stages with the highest degree of structural and biotic diversity (Figure 4.3-3).

Effects to species associated with wetland habitats would largely depend on changes in the ability of those areas to provide suitable habitat. Changes in water quality or hydrologic regime, for instance, may have negative effects on amphibian species that use wetlands for breeding. Loss of water during spring and summer, when eggs are laid and larvae develop, may eliminate some species from a particular site. On the other hand, a change to year-round standing water may allow the introduction of predators and competitors such as bullfrogs and fish. However, given that the site-specific policy objectives (no net loss of wetlands and protection of wetland functions) control individual silvicultural activities, it is not likely that there would be a material effect on wetland functions.

Section 4.9, Wetlands, addresses the effects of forest management on wetlands and the potential for the Alternatives to affect wetland quality. This discussion is summarized below. The difference in environmental effects to wetlands under Alternatives 1 through 6 would be a function of both the acres of trees harvested and the amount of related activities.



Under all Alternatives, non-forested wetlands would be protected with a no-harvest buffer. Timber harvest in surrounding forests may indirectly affect adjacent habitats by changing microclimatic conditions such as temperature, light, and hydrologic regimes. Some disturbance, localized clearing or loss of wetland acreage, may also occur (though no net loss of wetlands would occur—Forest Resource Plan Policy No. 21). In contrast, thinning (down to 120 square feet of basal area) would be allowed in forested wetlands under all of the Alternatives. A greater amount of harvest would carry a relatively greater potential risk of adverse effects to forested wetlands and the species associated with wetland habitat. Alternatives that result in a proportionally greater amount of harvest within the riparian land class would have a greater potential for effects to forested wetlands that occur within Riparian Management Zone boundaries.

Model results indicate that the greatest amount of timber harvest is anticipated under Alternative 6, followed in descending order by Alternatives 5, 2, 3, 4, and 1. This pattern is more marked within the riparian land class, where Alternative 6 is modeled as resulting in more than twice the rate of harvest as the next highest Alternative, Alternative 5 (Table 4.9-1). The amount of harvest in wetland and riparian habitats in the Olympic Experimental State Forest also differs among the Alternatives. Under Alternatives 1 and 4, the maximum percentage of the riparian land class harvested per decade in the Olympic Experimental State Forest would be below the maximum percentage per decade in the other five units combined (Table 4.3-2; percentages based on values in Table 4.3-1). The reverse would occur under Alternatives 2, 3, 5, and 6, and the harvest rate in the Olympic Experimental State Forest would exceed the rate elsewhere. The greatest amount of timber harvest activity in the riparian land class would occur under Alternatives 5 (maximum 33 percent) and 6 (maximum 73 percent). However, under Alternative 6, the great majority of riparian timber harvest would consist of low-intensity harvest (thinning).

Uncommon Habitats

Under Alternatives 2 through 6, legacy and reserve tree requirements in DNR Procedure 14-006-090 would be replaced with language implementing the protection of structurally unique trees and snags described in the Habitat Conservation Plan. The current requirement to retain 7 percent of the pre-harvest trees per acre would remain in place under Alternative 1 (No Action), and would be changed to the Plan's requirement of at least 8 trees per acre under the other Alternatives. Procedure 14-006-090 addresses retention of legacy trees in regeneration harvest areas, whereas the strategy in the Habitat Conservation Plan applies to all harvest types. Thus, although Alternatives 2 through 6 may marginally reduce the number of legacy trees that would be retained in regeneration harvest (assuming most stands selected for regeneration harvest have approximately 120 trees per acre greater than 12 inches diameter at breast height, the size specified in Procedure 14-006-090), they would be expected to result in a similar number of legacy tree retention overall, and pose no significant environmental impacts beyond existing conditions and those anticipated in the Habitat Conservation Plan Environmental Impact Statement.



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Retention of biological legacies (snags, down trees, and other woody debris) is an essential component of a management program designed to accelerate forest ecosystem development (Carey et al. 1996). Increased retention of legacy trees would be expected to increase habitat availability for many wildlife species (e.g., cavity-nesting birds) and help accelerate the rate at which structurally complex forest would develop in the planning area.

Of the other uncommon habitats addressed in this analysis, most are non-forested areas such as cliffs, caves, talus fields, and balds (grass- or moss-dominated forest openings), the amount of which is not expected to change in response to timber harvest activities. Oak woodlands are also considered uncommon habitats. Native oak is considered a non-commercial tree species, and as such is not included in timber harvest or type conversion under any of the Alternatives. Effects to uncommon habitats may occur, however, as a result of logging in adjacent commercial forest stands.

DNR procedures provide direction for protecting these habitats where they have been identified. Not all areas have been identified, however, and small patches (e.g., talus patches less than 1 acre, cliffs less than 25 feet high) receive no specific protection. Timber harvest in adjacent stands, therefore, carries the potential risk that personnel or equipment may damage these habitats, or disturb species that rely on them. Timber harvest may also indirectly affect adjacent habitats by changing microclimatic conditions such as temperature, light, and water movement. Road construction may also harm these habitats, although procedures direct DNR to avoid road construction through talus fields and balds where practicable.

The amount of timber harvest anticipated under each Alternative serves as an indicator of the relative risk of potential adverse effects to uncommon habitats. A higher rate of harvest suggests a greater potential risk of damage or disturbance to these habitats and associated species. Table 4.9-1 in Section 4.9 (Wetlands) summarizes the average harvest per decade under each Alternative. Overall, the greatest area of harvest is anticipated under Alternative 6, followed in descending order by Alternatives 5, 2, 3, 4, and 1. The amount of road construction is expected to be similar under all Alternatives. Though different levels of harvest are anticipated on lands adjacent to those containing uncommon habitats, no significant environmental effects beyond existing conditions and those described in the Habitat Conservation Plan Environmental Impact Statement are anticipated under any of the Alternatives when compared with Alternative 1 (No Action).

4.4.4.2 Species of Interest

Northern Spotted Owl

For this analysis, effects to the northern spotted owl were evaluated using three criteria:

- changes in the amount of structurally complex forest (i.e., habitat that approximates nesting, roosting, and foraging habitat);



- the amount of timber harvest in areas designated for nesting, roosting, and foraging habitat management; and
- changes in the management of owl circles.

Only one procedural change in the proposed Alternatives addresses the implementation of the Habitat Conservation Plan northern spotted owl conservation strategy. Changes to Procedure 14-004-120 would allow forest management in nesting, roosting, and foraging management areas where this habitat type is below designated threshold values. Under all six Alternatives, forest management in below-threshold nesting, roosting, and foraging management areas would continue because the Habitat Conservation Plan states that forest management (e.g., road construction, and timber harvest) can occur in nesting, roosting, and foraging habitat, as long as the modified stand continues to meet the definition of sub-mature habitat after management activities are complete. Thus, none of the Alternatives is expected to exceed the level of risk described in the Habitat Conservation Plan Environmental Impact Statement and agreed to by the Federal Services in charge of overseeing implementation of the Habitat Conservation Plan.

NESTING, ROOSTING, FORAGING, AND DISPERSAL HABITAT AVAILABILITY

As noted above, structurally complex forest is not the equivalent of nesting, roosting, and foraging habitat, and projections of future conditions are not a measure of DNR's success in meeting its obligations established under the Habitat Conservation Plan. Forested areas classified as structurally complex forest are likely to provide nesting, roosting, and foraging habitat to varying degrees, and, for this analysis, serve as an indicator for this habitat type. Differences in the amount of structurally complex forest on westside trust lands may indicate differences in the amount of suitable nesting, roosting, and foraging habitat that would be available under each Alternative over time. A qualitative discussion of the potential for the Alternatives to affect the amount and distribution of structurally complex forest among the planning units is presented in Section 4.4.4.1 above.

Alternatives with less intensive timber harvest would be expected to result in greater amounts of structurally complex forest in the short term, because comparatively few areas that currently provide structurally complex forest would be subject to heavy thinning or regeneration harvest. Results indicate that Alternative 1 (No Action) and Alternative 4 would result in the greatest overall increases in the amount of structurally complex forest in both the short term and the long term. Alternatives 5 and 6 would result in the smallest short-term increases. In the long term, however, both Alternatives 5 and 6 would exceed Alternative 3, and Alternative 6 would exceed Alternative 2 as well.

The amount of structurally complex forest in the Olympic Experimental State Forest merits particular attention because this planning unit has a different set of management strategies than the other planning units. Modeled changes in the amount of structurally complex forest cannot be used to judge whether management goals have been met, but they do allow a comparison of the relative rates at which desired habitat may develop under each Alternative. Alternatives 1 and 4 would result in the greatest short-term increases in the amount of structurally complex forest in the Olympic Experimental State Forest, exceeding 20 percent of that planning unit by 2013. The greatest long-term gains are modeled for



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Alternative 6, under which (along with Alternative 4) structurally complex forest would exceed 40 percent of the area of the Olympic Experimental State Forest by 2048, and would reach 68 percent by 2067. The smallest long-term gains are modeled for Alternatives 3 and 5.

In areas designated for nesting, roosting, and foraging habitat, intensive management under the biodiversity pathway approach of Alternative 6 would also be expected to result in long-term increases in structurally complex forest. Model results support this expectation. While the six Alternatives differ only slightly in the amount of structurally complex forest in nesting, roosting, and foraging management areas in the short term, long-term increases modeled for Alternative 6 would be more than double those for Alternatives 2, 3, or 5 (Table 4.4-3). The less-intensive approaches of Alternatives 1 (excluding more areas from timber harvest) and 4 (managing for an older average minimum regeneration age) would result in slightly smaller increases than Alternative 6. Compared to Alternatives 1 and 4, however, Alternative 6 would result in three times as much fully functional and niche diversification-stage forest in designated nesting, roosting, and foraging management areas.

Table 4.4-3. Acres of Structurally Complex Forests in Designated Nesting, Roosting, and Foraging and Dispersal Management Areas in 2067

	Current Conditions	1	2	Alternative			
				3	4	5	6
Nesting, Roosting, and Foraging Habitat Areas	17,000	71,000	42,000	34,000	62,000	31,000	86,000
Dispersal Habitat Areas	8,600	34,000	29,000	26,000	50,000	21,000	76,000

Data Source: Model output data – standard development stages

Similar to nesting, roosting, and foraging habitat, dispersal habitat would be expected to increase under all Alternatives, largely as a result of the development of structurally complex forest in areas that receive little or no timber harvest. In the short term, model results support that expectation, with Alternative 4 providing the greatest increases and Alternatives 2, 3, and 5 providing less (Appendix Table D-9). Alternative 6 stands out as providing the second-largest short-term increase and the largest long-term increase, due in part to widespread increases in average tree size following low-volume thinning treatments.

All six Alternatives would result in short- and long-term increases in the availability of structurally complex forest, both throughout the westside trust lands and in key management areas. In light of continued spotted owl population declines, the short-term effects of the Alternatives would likely have the greatest relative potential to influence the status of the owls in western Washington. Differences among the Alternatives are small in the short term, suggesting that all six Alternatives have a similar likelihood of minimizing the relative risks to spotted owls.



EFFECTS TO OWL CIRCLE HABITAT

Under all six Alternatives, habitat within “Memorandum 1” spotted owl circles would be released in 2007 for timber harvest consistent with the objectives and strategies of the Habitat Conservation Plan. Status 1-Reproductive and southwestern Washington circles would also be released in 2007 under Alternatives 3 through 6, and in 2004 under Alternative 2. Under Alternative 1, timber harvest deferrals in Status 1-Reproductive and southwest Washington circles are modeled as long-term deferrals. DNR and the Washington State Department of Fish and Wildlife developed an agreement for managing harvest activities in four southwest Washington circles. This agreement is scheduled to remain in effect until 2006. The agreement was reached after modeling was completed for Alternative 1, and is not reflected in the model or modeling outputs.

Timber harvest in spotted owl circles may reduce or eliminate the habitat available for some spotted owl pairs, but the extent to which this may occur is uncertain. In addition, significant adverse environmental effects to the western Washington spotted owl population beyond existing conditions and the effects anticipated in the Habitat Conservation Plan Environmental Impact Statement are unlikely. In approving DNR’s Habitat Conservation Plan, the U.S. Fish and Wildlife Service determined that this species would be best served by the protection of habitat in certain key areas (DNR 1997). The protection of the specified circles was seen as necessary for a limited time period. Risks associated with the loss of reproductive owls outside those areas were considered acceptable in light of gains in long-term habitat availability. The Habitat Conservation Plan has a landscape-level focus on population dynamics rather than relying on the protection of individual spotted owls.

Many owl circles are currently unoccupied, and likely to remain so (personal communication, S. Horton, Wildlife Biologist, DNR, 12 August 2003). Lastly, land ownership within owl circles typically consists of a mix of state, private, and federal lands. Even if DNR is no longer required to maintain suitable habitat on state trust lands, State Forest Practices Rules still closely regulate the harvest of habitat in Spotted Owl Special Emphasis Areas. Some suitable habitat would likely remain within owl circles in these emphasis areas.

It should be noted that state lands deemed to have the greatest potential of providing an appreciable contribution to the maintenance of spotted owl populations were identified during the development of the DNR’s Habitat Conservation Plan (1997), and designated as nesting, roosting, and foraging management areas. Based on the analyses conducted for that plan, potential negative effects to individual spotted owls outside those areas are not expected to result in significant adverse effects to recovery efforts for the spotted owl population in western Washington.

TIMBER HARVEST IN AREAS DESIGNATED FOR NESTING, ROOSTING, AND FORAGING HABITAT MANAGEMENT

All of the Alternatives are consistent with the Habitat Conservation Plan strategy for the spotted owl. None would allow activities that would reduce the amount of nesting, roosting, and foraging habitat in below-threshold watersheds, or delay the future



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development of this habitat. Alternative 1 would be expected to result in the least forest management in areas designated for nesting, roosting, and foraging management, and Alternative 6 the most. Model results support this expectation (Table 4.4-4). Alternative 6 would result in the highest level of forest management activity in areas designated for nesting, roosting, and foraging habitat management, with an average of 32 percent of such areas harvested per decade. This level is slightly higher than the rate of forest management activities expected for westside trust lands as a whole, indicating an active approach to managing spotted owl habitat using biodiversity pathways techniques. Under the other Alternatives, designated nesting, roosting, and foraging management areas would be harvested at a lower rate than the rate for all lands. Alternative 1 is expected to have the least harvest in designated nesting, roosting, and foraging management areas. Alternative 4, with an older average minimum regeneration age and a relatively low rate of harvest overall, results in the second lowest harvest rate in designated nesting, roosting, and foraging management areas. Alternatives 2 and 3 result in similar (and moderate) amounts, and Alternative 5 is exceeded only by Alternative 6.

Table 4.4-4. Average Percent of Designated Nesting, Roosting, and Foraging Management Areas Harvested under Each Alternative per Decade at Various Harvest Volume Classes, Compared to the Average Harvest Rate in All Areas

Alternative	Percent of Designated Nesting, Roosting, and Foraging Management Areas				Percent of Westside Trust Lands Harvest per Decade
	Volume Removal Class			Total	
	Low	Moderate	High		
1	0%	1%	1%	2%	12%
2	4%	4%	6%	14%	17%
3	2%	2%	8%	12%	18%
4	3%	2%	3%	8%	14%
5	7%	5%	8%	20%	26%
6	18%	9%	5%	32%	31%

Data Source: Model output data – timber flow levels

Notably, the majority of harvest in designated nesting, roosting, and foraging management areas under Alternative 6 would consist of thinning (low- and moderate-volume removal harvest), and would therefore be expected to maintain or improve habitat conditions, or increase the potential of a stand to becoming nesting, roosting, and foraging habitat sooner. Only 15 percent of timber harvest in designated nesting, roosting, and foraging management areas under Alternative 6 would consist of heavy thinning or regeneration harvest (high-volume removal harvest) compared to 36 to 62 percent under the other Alternatives. Overall, the greatest amount of high-volume removal harvest in designated nesting, roosting, and foraging management areas would occur under Alternative 5, followed in descending order by Alternatives 3, 2, 6, 4, and 1.



Marbled Murrelet

All Alternatives are consistent with implementation of the Habitat Conservation Plan conservation strategy for marbled murrelets. The variables are the amount of structurally complex forest (the habitat most likely to provide suitable nesting habitat) on DNR-managed westside trust lands and timing of when such habitat would appear on the landscape. Section 4.4.4.1 provides a qualitative assessment of the potential for the Alternatives to affect the quantity and distribution of structurally complex forest on westside trust lands. In both the short term and long term, Alternatives 1 and 4 are expected to provide the greatest amount of structurally complex forest on westside trust lands, and Alternative 5 the least. Model results show Alternative 6 as providing a moderate increase in structurally complex forest in the short term, and nearly as much as Alternatives 1 and 4 in the long term.

The amount of structurally complex forest habitat within 40 miles of marine waters is of particular concern, because the great majority of known marbled murrelet nest sites occur within this band (USFWS 1997). Within the 40 miles, the Alternatives provide equal murrelet nesting habitat. Appendix Table D-10 presents the results of this analysis. In general, the overall pattern of habitat increases in all areas under all Alternatives holds true when the analysis is limited to watersheds that are mostly or entirely within 40 miles of marine waters.

Other Threatened, Endangered, and Sensitive Species

None of the Alternatives proposes changes in the policies or procedures that directly address threatened, endangered, and sensitive species, other than the northern spotted owl and legacy and reserve tree procedures. Therefore, differences among the Alternatives would arise from differences in the amount or quality of the habitats with which these species are associated. Most of these species are associated with non-forested habitats. The availability of such habitats is not expected to change in response to timber harvest activities, but habitat quality can be affected by harvest of adjacent stands. In addition, harvest activities in adjoining forest stands may affect species viability by flushing adults from nests or dens and leaving the young exposed to an increased risk of predation or starvation.

Analysis of effects to most other species of management concern, therefore, focuses on the differences in the amount of timber harvest modeled under each Alternative, or the potential effects to the habitats with which they are associated, within the planning units where the species may occur. Greater detail about effects to species associated with structurally complex forest, riparian, wetland, and uncommon habitats can be found in Section 4.4.4.1. Table 4.4-5 lists the criteria by which effects of the Alternatives were evaluated for each species (evaluation criteria are based on the habitat associations and distribution information in Appendix Table D-7), and ranks the Alternatives with respect to these criteria. Alternatives with the least potential to result in adverse effects are listed first, followed by those with increasing potential for adverse effects.



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Table 4.4-5. Criteria for Evaluation of the Effects to Threatened, Endangered, and Sensitive Species Other Than Northern Spotted Owl and Marbled Murrelet

Species	Evaluation Criteria ^{1/} (Planning Units Where Effects May Occur)	Relative Ranking by Alternative ^{2/}
Mardon Skipper	Effects to uncommon habitats (South Puget and South Coast)	1 4 3 2 5 6
Oregon Silverspot Butterfly	Effects to uncommon habitats (South Coast)	1 4 2 3 5 6
Larch Mountain Salamander	(a) Effects to uncommon habitats (b) Amount of structurally complex forest in 2013 (North Puget, South Puget, and Columbia)	(a) 1 4 2 3 5 6 (b) 4 1 2 3 6 5
Oregon Spotted Frog	Effects to wetlands (South Puget and Columbia)	1 4 2 3 5 6
Western Pond Turtle	Effects to wetlands (North Puget, South Puget, Columbia, and South Coast)	1 4 2 3 5 6
Common Loon	Amount of timber harvest (all planning units except Columbia)	1 4 2 3 5 6
Aleutian Canada Goose	Effects to wetlands (North Puget, South Puget, Columbia, and South Coast)	1 4 2 3 5 6
Bald Eagle	Amount of structurally complex forest, (a) short-term and (b) long-term (all planning units)	(a) 4 1 2 3 6 5 (b) 4 1 6 2 3 5
Peregrine Falcon	(a) Amount of timber harvest activity; (b) effects to wetlands (all planning units)	(a) 1 4 2 3 5 6 (b) 1 4 2 3 5 6
Sandhill Crane	Effects to wetlands (Columbia)	1 4 2 3 5 6
Western Gray Squirrel	Amount of timber harvest (South Puget and Columbia)	1 4 2 3 5 6
Gray Wolf	Amount of timber harvest (North Puget, South Puget, and Columbia)	1 4 2 3 5 6
Grizzly Bear	Amount of timber harvest (North Puget and South Puget)	1 4 3 2 5 6
Pacific Fisher	Amount of structurally complex forest in low-elevation watersheds ^{3/5/}	4 1 6 2 3 5
Canada Lynx	Harvest activity in high-elevation watersheds ^{4/5/} (North Puget, South Puget, and Columbia)	6 5 2 3 4 1
Columbian White-tailed Deer	Effects to riparian areas (Columbia)	1 4 2 3 5 6

^{1/} See Appendix Table D-7 for the habitat association and distribution information that serves as the basis for these evaluation criteria.

^{2/} Alternatives with the least potential to result in adverse effects are listed first, followed by those with increasing potential for adverse effects.

^{3/} Defined as watersheds where >50% of DNR land is in the western hemlock or sitka spruce vegetation zones.

^{4/} Defined as watersheds where >1% of DNR land is in the alpine or parkland vegetation zone, and >30% is in any combination of the parkland, mountain hemlock, and Pacific silver fir zones.

^{5/} The term “watershed” is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

Data Source: Model output data – stand development stages

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Two species, Pacific fisher and Canada lynx, receive additional discussion below. In the case of the lynx, only a few watersheds in the North Puget Planning Unit contain suitable habitat.

Pacific fisher are associated with structurally complex forest, particularly at low elevations. Timber harvest that reduces canopy cover and the availability of large snags and coarse woody debris may decrease the potential for a landscape to support this species (Lewis and Stinson 1998). In western Washington, most low-elevation forest falls in the western hemlock or Sitka spruce potential vegetation zone, which are also the most productive zones for timber (see Section 4.2 for a discussion of vegetation zones). None of the Alternatives contains any specific provisions for the protection of low-elevation forest, and most would be expected to emphasize timber production from these areas; however, extensive acreage is dedicated to conservation benefits or other resource protection objectives that provide direct and indirect benefits to a number of species. The amount of forest management activities may potentially be offset by the relatively faster development of structurally complex forest in these more productive areas. The rate and amount would vary by Alternatives. Model results support this assumption, predicting greater increases in the availability of structurally complex forest in low-elevation areas compared to overall (Appendix Table D-11).

An analysis of the net change in the availability of structurally complex forest in watersheds that are dominated by low-elevation vegetation shows a pattern similar to that modeled for structurally complex forest overall (Appendix Table D-11; compare to Appendix Table D-8). In both analyses, increases from current conditions result in all time periods under all Alternatives, with the greatest short- and long-term increases anticipated under Alternatives 1 and 4.

One key difference is that all Alternatives show greater increases in structurally complex forest in low-elevation areas compared to overall. This is particularly evident by year 2067, when low-elevation increases exceed overall increases by 16 percentage points under Alternatives 1 and 4, likely due to the faster rate of development of structurally complex forest in more productive areas. Smaller differences under Alternatives 6 (3 percentage points), 2, and 3 (8 percentage points each) may indicate a comparatively higher rate of timber harvest in low-elevation areas under these Alternatives. No significant impacts beyond existing conditions and the effects anticipated in the Habitat Conservation Plan Environmental Impact Statement are expected to low elevation structurally complex forests, or by association, Pacific fisher and its habitat.

Canada lynx are associated with high-elevation areas in the state of Washington. Most westside state trust lands are in lower elevation areas; only 10 watersheds (all in the North Puget Planning Unit) meet the criterion of at least 1 percent of DNR lands in the alpine or parkland zone, along with some area in mountain hemlock and/or Pacific silver fir. Dense, young forest provides suitable foraging habitat for lynx; thus, timber harvest in watersheds with high-elevation areas may improve habitat conditions for this species. Any benefits of habitat improvement may be partially offset by disturbance to animals during harvest activities (of particular concern if lynx are breeding in the vicinity), and possible



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reductions in the availability of down woody debris, which provides cover and den sites. Model results indicate that the greatest amount of timber harvest in high-elevation watersheds is anticipated under Alternative 6, followed in descending order by Alternatives 5, 3, 2, 4, and 1. The proportion of trust land harvested in these watersheds per decade ranges from 9 percent (Alternative 6) to 5 percent (Alternative 1), well below the proportions modeled for all westside trust lands (see Table 4.9.1). No significant adverse impacts are therefore anticipated to Canada lynx under Alternatives 2 through 6 relative to Alternative 1 (No Action).

Deer and Elk

Effects of the Alternatives on deer and elk can be evaluated by comparing the number of watersheds in which the amount of deer and elk foraging habitat on trust lands is between 30 and 60 percent of the total DNR-managed area. This proportion of foraging habitat ensures ample foraging opportunities for these species, without compromising the availability of densely forested areas that provide cover. For this analysis, ecosystem initiation forest, structurally complex forest, and open-canopy forest in the understory reinitiation stage are all considered to provide foraging habitat. Currently, the great majority of westside trust lands are in competitive exclusion forest that does not provide foraging habitat. Thus, Alternatives that result in the greatest amount of open or structurally complex forest—or both—would be expected to provide the greatest improvements in habitat conditions for these species.

In almost all time periods, results suggest that all six Alternatives would result in increases in the number of watersheds in which foraging habitat makes up between 30 and 60 percent of DNR-managed land (Table 4.4-6). In the short term, Alternatives 4 and 5 result in the greatest improvements. Alternative 5, which emphasizes revenue production with shorter rotation cycles and more intensive activities, produces the greatest increase in

Table 4.4-6. Change Over Time Relative to the Current (2004) Number of Watersheds^{1/} in which 30 to 60 Percent of State Trust Lands Would Provide Deer and Elk Foraging Habitat, under each Alternative

Change in Number of Watersheds with 30% to 60% Forage					
Alternative	Year 2008	Year 2013	Year 2031	Year 2048	Year 2067
1	+ 6	+ 20	+ 41	+ 48	+ 35
2	+ 8	+ 20	+ 52	+ 62	+ 94
3	+ 2	+ 21	+ 40	+ 88	+ 78
4	+ 14	+ 36	+ 30	+ 40	+ 27
5	+ 16	+ 29	+ 73	+ 74	+ 75
6	- 4	+ 11	+ 46	+ 43	+ 28

Data Source: Model output data – stand development stages

^{1/} The term “watershed” is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations



2008, presumably because it results in the sharpest increase in the amount of ecosystem initiation forest. Alternative 4, which employs a more passive management approach to resource protection, results in the greatest increase in 2013, likely associated with the increased availability of structurally complex forest. Alternatives 1, 2, and 3 result in smaller increases that are nearly equal in 2013, while the smallest short-term increase is modeled as occurring under Alternative 6.

Over the long term, Alternative 2 (as modeled) results in steady increases in the number of watersheds with 30 to 60 percent foraging habitat, producing the greatest increase by the year 2067, the end of the planning period. Short-term increases under Alternative 4 do not continue into the long term; instead, the number of watersheds in the optimum range levels off. Alternative 4 has the smallest increases in 2031 and thereafter.

Alternatives 1, 5, and 6 show similar leveling trends after 2031, while Alternative 3 increases through 2048 and then decreases. By 2067, the nominal duration of the Habitat Conservation Plan, Alternative 2 results in the greatest increase in the number of watersheds with 30 to 60 percent foraging habitat, followed in descending order by Alternatives 3, 5, 1, 6, and 4. Despite differences in the amount of deer and elk foraging habitat created, significant environmental impacts beyond existing conditions are not anticipated in any of the six Alternatives. All projected gains in foraging habitat for deer and elk for Alternatives 2 through 6 are comparable or greater than those found in Alternative 1 (No Action).



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4.5 AIR QUALITY

4.5.1 Summary of Effects

This section analyzes the environmental effects on air quality. The analysis examines the effects of prospective changes to current policy and procedures, and uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

None of the proposed Alternatives would create new policies or procedures related to air quality. Impacts related to air quality would result from the projected forest management activities associated with each of the Alternatives. Air pollution from dust would be mitigated by dust abatement measures under all Alternatives, and the total amount of prescribed burning would likely continue to be below the level anticipated in the Habitat Conservation Plan.

The Alternatives differ slightly in their effects to air quality, but none of the Alternatives has the potential for significant environmental impacts beyond existing conditions and the effects anticipated in the Habitat Conservation Plan Environmental Impact Statement.

4.5.2 Affected Environment

Air quality is regulated by the federal Clean Air Act, which requires the Environmental Protection Agency to set national ambient air quality standards for pollutants considered harmful to public health and the environment. “Ambient air” refers to that portion of the atmosphere, external to buildings, to which the general public has access. An air quality standard establishes values for maximum acceptable concentration, exposure time, and frequency of occurrence of one or more air contaminants in the ambient air. Ambient air quality standards have been set for six principal pollutants: carbon monoxide, nitrogen dioxide, ozone, lead, particulate matter, and sulfur dioxide.

Prescribed burning on forest land is regulated by DNR’s Resource Protection Division, which requires a permit for burning. DNR’s smoke management plan provides regulatory direction, operating procedures, and information regarding the management of smoke and fuels on the forestlands of Washington. The plan coordinates and facilitates the statewide regulation of prescribed burning on DNR trust lands, as well as on federally managed forestlands and participating tribal lands. The plan is designed to meet the requirements of the Washington State Clean Air Act.

Other activities on DNR-managed westside trust lands that may affect air quality are regulated by regional agencies responsible for enforcing air quality laws in Washington. These agencies regulate a wide range of air pollution sources. They also monitor air quality.

The main sources of air pollution in western Washington include motor vehicles (55 percent), industrial (13 percent), and wood stoves (9 percent). Approximately



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4 percent is generated from outdoor burning, a portion of which comes from forest management activities (Washington State Department of Ecology 2003). Air quality in western Washington is generally good or moderate, although some areas do not meet federal standards on some days. Air quality has improved greatly since 1987, when Washington violated air quality standards on 150 days. This figure dropped to 7 in 1999 (Washington State Department of Ecology 2003).

4.5.2.1 Silvicultural Burning

Broadcast burning is the practice of burning logging slash scattered throughout a recently harvested unit to prepare the site for planting and/or to reduce dangerous fuel loads. Between 1997 and 2002, approximately 15 acres of DNR-managed westside trust lands were broadcast burned each year to reduce slash, considerably less than the 500 to 1,000 acres anticipated in the Habitat Conservation Plan Environmental Impact Statement (DNR 1996).

During this same period, approximately 269 acres per year of pile burning took place. This is the practice of reducing logging slash by collecting the slash in piles and burning the piles. By burning under wetter conditions, usually in the spring, fewer particulates are emitted than would be the case if the same fuels burned in a wildfire. Particulate emissions from wildfires are, on average, three to four times higher than from prescribed burning (DNR 1996). Wildfire risk is discussed in Section 4.2 (Forest Structure and Vegetation).

4.5.2.2 Air-borne Dust

The use of logging roads during dry periods generates air-borne dust. Air-borne dust is regulated through road maintenance standards of the Washington Forest Practices Board (Washington Administrative Code 222-24) and safety standards of the Washington Department of Labor and Industries (Washington Administrative Code 296-54). The amount of air-borne dust is a function of road use and surfacing material. Gravel can reduce dust (Washington State Department of Ecology 2001) as can water and chemical dust (DNR 1996) suppressants. In general, the adverse effects of air-borne dust are localized and short term (DNR 1996).

4.5.2.3 Forest Land and Air Quality

One of the ecological benefits of forested lands is the enhancement of air quality. Plants enhance air quality by emitting oxygen and consuming carbon dioxide, the gas most associated with global warming (see Section 4.2 for a discussion of the carbon cycle and carbon sequestration). In addition, trees retard the spread of airborne particulates by trapping the material on their leaf surfaces and by slowing the wind speed to the point that particulates cannot remain suspended. Timber harvesting temporarily removes the air quality benefits provided by trees (DNR 1996).



4.5.3 Environmental Effects

Impacts related to air quality would be minor under all Alternatives. Traffic on dirt roads would add dust to the air, and prescribed burning and wildfires would add smoke. The dust and smoke could produce eye and respiratory discomfort to people working, living, or recreating in the area. Smoke, especially from wildfires, could adversely affect air quality over a wide area, which could include urban areas.

Alternatives 5 and 6 are projected to harvest more timber than the other Alternatives (approximately twice the level projected for Alternatives 1 and 4). This harvest activity is likely to result in more traffic by log trucks and vehicles driven by other forest workers. Alternatives 5 and 6 would, therefore, have a greater potential to generate dust than the other Alternatives. Alternatives 1 and 4 are projected to have the lowest harvest levels over the planning period, and would, therefore, have a lower potential to generate dust. Alternatives 2 and 3 are intermediate. Air pollution from dust would be mitigated by dust abatement measures under all Alternatives.

The use of prescribed burning to prepare a site for planting is projected to be similar to current levels under all of the Alternatives. It is likely to be slightly lower under Alternatives 4 and 6 and slightly higher under Alternatives 2 and 3. Any burning would be regulated by the Washington State Smoke Management Plan. Few or no additional adverse effects on air quality are anticipated to result from prescribed burning for site preparation under any of the proposed Alternatives. Policy No. 10 of the Forest Resource Plan directs DNR to take preventive measures to reduce extreme fire hazards on DNR lands. This is not anticipated to result in many acres of prescribed burning on the westside due to cool and wet weather patterns that generally prevail. The sum of all prescribed burning is likely to continue to be below the level anticipated in the Habitat Conservation Plan.



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4.6 GEOMORPHOLOGY, SOILS, AND SEDIMENT

4.6.1 Summary of Effects

This section analyzes the environmental effects on geomorphology, soils, and sediment. The analysis examines the current policy and procedures and uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts of the Alternatives. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

Significant increases in landslide frequency or severity and loss of soil productivity are not anticipated under any of the six Alternatives. Increased soil erosion may occur in certain intensely managed areas as road use increases. Further discussion of relative impacts among planning units and for individual watersheds is included in Cumulative Effects (Section 4.15). Alternative 6 carries the highest potential overall relative impact, followed by Alternatives 5, 3, 2, 4, and 1.

4.6.2 Introduction

Geomorphology, soils, and sediment in western Washington are products of interactions among the geology, climate, and ecosystems. Timber harvest can have environmental effects on these resources. Issues related to geomorphology, soils, and sediment identified during scoping include sediment movement and soil productivity. Sediment movement is important because mass movement and surface erosion delivered to streams can result in adverse effects to fish and aquatic habitat.

As discussed in Forest Practices Rules Environmental Impact Statement, Section 3 (Washington Forest Practices Board 2001), mass wasting may deliver large volumes of coarse sediment and some fine sediment to streams, which may result in pool filling and loss of rearing habitat. Surface erosion primarily delivers fine sediment to streams, which may result in degradation of spawning habitat.

Soil is an important resource because it provides the medium for the growth of trees and other vegetation, and is a key factor in the productivity of forests.

4.6.3 Affected Environment

The following descriptions of the affected environment with respect to mass wasting, surface erosion, and soil productivity were synthesized largely from information presented in the 1997 Habitat Conservation Plan and the 2001 Forest Practices Rules Environmental Impact Statement (Washington Forest Practices Board 2001). These were supplemented with peer-reviewed references and data generated from the Alternatives modeling analysis. As part of their project requirements, DNR evaluates geomorphological interactions during site-specific design. An understanding of interactions among geology, climate, and ecosystems leads to balanced actions that reduce significant adverse environmental impacts. Understanding landforms and ecosystem processes, both biotic and abiotic, increases conservation benefits while meeting fiduciary responsibilities.



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A number of key processes are important in understanding the potential for significant adverse environmental impacts. These include mass wasting, surface erosion, and soil productivity, which are discussed below.

4.6.3.1 Mass Wasting

Mass wasting events provide episodic sources of fine and coarse sediment and organic debris to the aquatic systems in western Washington. Various types of landslide detachments and processes can be considered mass wasting. Some are deep-seated, in which most of the area of the slide plane or zone lies beneath the maximum rooting depth of forest trees, sometimes to depths of tens or hundreds of feet. Others are shallow-rapid, in which the landslide plane or zone is within the maximum rooting depth of forest trees. Further distinctions can be made based on the failure mechanism and composition of the resulting debris flow. A landslide may turn into a debris flow or debris torrent. Debris flows or torrents may transport more material than the original failure because they may also scour stream channels (Section 3.2, Washington Forest Practices Board 2001).

Landslides are the result of failure of the cohesive strength of the slope material (e.g., vegetation, soil, subsurface deposits). This loss of cohesive strength can be caused by a variety of factors, including loss of root strength, increased pore-water pressure, or inherently low shear strength of subsurface materials. Slope length, shape, and aspect are also natural variables that influence landslide risk for a given slope. Mass wasting events generally correlate with high precipitation events, changes in drainage, removal of vegetation, or removal of material downslope of the failure. Additionally, stream banks may be susceptible to failure if streamside vegetation is removed. See the Forest Practices Rules Environmental Impact Statement, page 3-10 (Washington Forest Practices Board 2001) for further discussion.

Management activities that potentially increase the risk of mass wasting include road building and timber harvest (Washington Forest Practices Board 2001). Road location, drainage, design, construction, and maintenance can either increase or reduce the risk of mass wasting and its effects. Sediment produced as a result of forest management activities can be delivered to the aquatic system from episodic landslides initiated in harvested areas on unstable slopes. The role of mass wasting in aquatic systems is described in more detail in the Forest Practices Rules Environmental Impact Statement (pages 3-7 through 3-25, Washington Forest Practices Board 2001). Potential impacts from road building and timber harvest are minimized through effective planning, design, and review of appropriate harvest practices on unstable or potentially unstable slopes.

4.6.3.2 Surface Erosion

Generally, forest vegetation stabilizes soils, reduces soil erosion, and slows sediment transport to streams, thereby minimizing the impact of sedimentation on water quality. However, surface erosion from roads, harvest units, and skid trails tends to be a chronic source of fine sediment to the drainage network, as well as an episodic source of coarse sediment. Chronic sources of fine sediment can potentially have significant adverse effects



on the physical habitat of the aquatic system and certain lifestages of aquatic biota, as well as degrade water quality.

Road-related surface erosion and delivery of fine sediments to streams is a concern because of the thousands of miles of forest roads that exist to transport harvested timber in forested regions of western Washington. Surface erosion depends on slope gradient and shape, soil texture, parent material, precipitation, groundwater movement, and vegetation cover. The amount and types of traffic and road maintenance practices also influence delivery.

Harvest activities such as ground-based skidding or cable yarding can cause soil disturbance. Streamside vegetation and hillslope roughness can trap sediment, minimizing the amount that reaches the stream system. These filtering capabilities are affected by timber harvest within streamside buffers. However, additional harvest materials left on the forest floor can offset decreases near the streamside buffer. See the Forest Practices Rules Final Environmental Impact Statement (page 3-9, Washington Forest Practices Board 2001) and the Habitat Conservation Plan Final Environmental Impact Statement (DNR 1996, Sections 4.2.3, 4.4.2, and 4.6).

4.6.3.3 Soil Productivity

Soil productivity is a soil's capacity to support vegetation. Long-term productivity is a soil's capacity to sustain the natural growth potential of plants over time (Section 4.6 of the Habitat Conservation Plan Environmental Impact Statement). Forest management relies on soil productivity to provide conservation benefits and to support a productive forest ecosystem that provides financial support to the beneficiaries.

Soil productivity is a function of a variety of parameters, both within the soil and external to it. Internal parameters include bulk density or porosity, amount of organic matter, and levels of carbon, nitrogen, and other beneficial minerals, as well as the presence of organisms within the soil (e.g., earthworms, mycorrhizal fungi) that aerate the soil or allow plants to uptake nutrients from the soil. External conditions, such as climate, slope aspect, and precipitation will also influence internal conditions of soil temperature and soil moisture.

Timber harvest and road building can affect soil productivity. Factors involved include harvest location relative to sensitive soils and soil moisture; type, area, and frequency of disturbance related to harvest; the amount of large wood left on site; reforestation methods; and fertilization. Disturbance from felling, yarding, and skid trails can cause soil compaction, which can affect soil productivity (page 3-9, Washington Forest Practices Board 2001). Burning and mechanical clearing have the potential to reduce soil productivity for sensitive soils.

Productivity can be degraded or improved by forest management in a variety of ways (USDA Forest Service 2002b, Heninger et al. 2002, Miller et al. 1992). Removal of trees and site preparation can increase soil temperature and erosion; yarding and felling can



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compact soils or remove organic layers if trees are pushed or dragged along the ground surface; and burning can change the mineralogy of soil and decrease nutrient content. Adverse impacts may be amended or masked by human inputs. Fertilization and control of undesirable vegetation may improve the productivity of desirable species. However, the influence of management activities on soil productivity depends on the type, timing, and intensity of management, as well as the original soil and site qualities. The significance of management activities depends on the degree they affect ecosystem processes or plant and animal communities.

Harvest and Reforestation Methods

The methods used to harvest trees can affect soil health and productivity. Ground-based systems and cable systems without full suspension have the greatest potential to increase compaction or surface erosion, which can decrease soil productivity for some soils.

Forest fertilization can improve financial yields and may improve forest health for some sites. Fertilization includes both aerial and ground applications. Other practices such as site preparation and vegetation management are important management tools to either protect or increase financial yields. Site preparation includes a variety of techniques, such as aerial and ground herbicide applications, broadcast burns, ground mechanical treatments, and pile and burn. Vegetation management includes aerial and ground herbicide applications, and mechanical and hand vegetative control methods. The policy preference established in Forest Resource Plan Policy No. 33 determines operational application of these practices.

4.6.3.4 Existing Conditions on Western Washington DNR-Managed Lands Mass Wasting

Deep-seated landslides occur on less than 5 percent of forested DNR lands in western Washington (Table 4.6-1). Areas with a high potential for shallow-rapid landslides represent approximately 10 to 15 percent of forested DNR-managed lands in western Washington. These areas are more susceptible to mass wasting under certain types of forest management. The greatest area of potentially unstable slopes is in the North Puget Planning Unit.

Soil Productivity

Over half of the forested DNR-managed westside trust lands can be characterized as having a high potential for soil compaction (Table 4.6-2). Additionally, half of the DNR-managed westside trust lands have been evaluated for response to fertilization. Of the lands evaluated, approximately 40 percent have a low-to-medium response rate to fertilization and only 10 percent have a high response rate. Almost 45 percent of these lands have a low potential for burn damage, and approximately 20 percent have a high potential.



Table 4.6-1. Areas of Deep-Seated Landslides and Potentially Unstable Slopes on DNR Lands in Western Washington, by Planning Unit

Planning Unit	Acres of Identified Deep-Seated Landslides ^{1/}	Acres of Landslides that Have Occurred ^{2/}	Acres Designated as High for Potential Slope Instability ^{3/}
Columbia	8,282	171	16,525
North Puget	13,476	2,146	52,388
OESF	2,886	1,646	53,296
South Coast	5,478	261	23,254
South Puget	890	3,252	11,560
Straits	1,851	3	14,157
Total	32,864	7,479	171,181

Data Sources:

^{1/} DNR Geoslide Geographic Information System Data

^{2/} DNR Landslide Geographic Information System Data

^{3/} DNR SMORPH Geographic Information System Data (10-meter slope stability model)

OESF = Olympic Experimental State Forest

SITE INDEX CLASSIFICATION

Site index is a measure of soil productivity, expressed as the height of the dominant trees in a stand at a given age. These indices are grouped into site classes (I through V), each of which corresponds with a range in tree heights. Class I corresponds with the tallest trees, and therefore generally the most productive soils. Class V corresponds with shorter trees, and therefore generally the least productive soils. Less than 5 percent of the westside trust lands is classified as Class I (the most productive class) (Table 4.6-2). Throughout the forested DNR westside trust lands, most areas are classified in site classes II and III. Less than 5 percent is classified as Class V (the least productive class). This information is broken down by planning unit in Table 4.6-3.

FERTILIZER RESPONSE AND SITE PREPARATION

Table 4.6-3 also shows the fertilizer response of soils on DNR-managed westside lands where data are available. The lands evaluated are approximately equally distributed among low, medium, and high for fertilizer response. Since 1993, between 2,251 and 20,944 acres of forested DNR-managed lands in western Washington were fertilized each year to increase productivity. As shown in Table 4.6-4, the maximum area that fertilizer was applied to in a given year was 10,811 acres. Since 2000, fertilizer use has decreased to approximately 300 acres per year of biosolid application.

Acres of DNR-managed westside lands on which various site preparation methods were applied varied from 75 to 5,900 acres between 1993 and 2002 (Table 4.6.4). Since 1993, vegetation management techniques have been applied to a minimum of 2,176 acres in 1994 and a maximum of 13,305 acres in 2001.



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Table 4.6-2. Site Class, Compaction Potential, Fertilizer Response, and Burn Damage Potential by Land Classification (Percent Area)

Land Classification	Uplands with General Objectives	Riparian	Uplands with Specific Objectives	Total Westside
Moist Soil Compaction Potential				
High	70	67	59	64
Low	4	4	6	5
Medium	22	22	27	24
N/A	0	1	2	1
No Data	3	5	7	5
Variable	0	1	0	1
Fertilizer Response				
High	17	9	13	13
Low	34	19	9	18
Medium	23	15	15	17
No Data	26	56	63	51
Burn Damage Potential				
High	18	16	27	22
Low	48	49	34	42
Medium	30	28	30	29
N/A	1	2	2	2
No Data	3	5	7	5
Variable	0	0	0	0
Site Class (Site Index)				
I (143)	6	4	2	4
II (127)	44	30	21	30
III (109)	38	45	46	44
IV (89)	10	17	24	18
V (69)	2	4	8	5

Environmental Effects

Potential environmental impacts of the Alternatives on geomorphology, sediment, and soils are discussed in terms of changes proposed to policies and procedures, as well as changes to harvest levels and management. Effects on water quality and fish are further discussed in Sections 4.8 (Water Quality) and 4.10 (Fish).

4.6.3.5 Comparison of Alternatives

Impacts to forest soils on DNR-managed lands that may result from implementation of the various Alternatives are analyzed in terms of the potential for displacement and loss of soil through mass wasting, potential for changes in surface erosion, and potential for changes in soil productivity. Common to all Alternatives is the existing roaded area on DNR-managed lands. All road maintenance and abandonment will be accomplished following DNR policies and procedures for all Alternatives. Over the course of the time period covered by the modeling, no significant net changes to roaded area or practices related to road location or construction are anticipated under any of the Alternatives beyond existing

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Table 4.6-3. Site Class, Compaction Potential, Fertilizer Response, and Burn Damage Potential by Planning Unit (Percent Area)

	Percent Area by Planning Unit						
	Columbia	N. Puget	OESF ^{1/}	S. Coast	S. Puget	Straits	Westside
Compaction Potential							
High	60	75	64	94	30	22	64
Low	1	3	No data	1	24	13	5
Medium	28	11	34	4	43	57	24
N/A	0	4	0	0	1	1	1
No Data	9	7	2	1	3	7	5
Variable	2	0	0	0	0	0	1
Fertilizer Response							
High	14	6	No data	3	29	62	13
Low	36	3	No data	57	11	1	18
Medium	27	18	0	16	26	24	17
No Data	23	72	100	24	34	12	51
Burn Damage Potential							
High	14	32	No data	3	60	43	22
Low	51	6	76	84	19	12	42
Medium	23	51	22	11	17	38	29
N/A	0	4	0	0	1	1	2
No Data	9	7	2	1	3	7	5
Variable	2	0	0	0	0	0	0
Site Class (Site Index)							
I (143)	3	4	1	10	1	0	0
II (127)	37	25	14	60	22	9	9
III (109)	38	40	61	28	49	57	57
IV (89)	18	20	21	2	25	30	30
V (69)	3	11	3	1	3	4	4
Data Source: DNR Soils Layer							
^{1/} OESF = Olympic Experimental State Forest							



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Table 4.6-4. Area of Fertilization, Site Preparation, or Vegetation Management in Forested DNR Lands in Western Washington between 1993 and 2002 (acres)

Year Completed	Area Fertilized	Area of Site Preparation	Area of Vegetation Management	Total Area Treated
1993	<1	146	7,070	7,216
1994	<1	75	2,176	2,251
1995	20	165	4,478	4,663
1996	762	173	3,960	4,895
1997	711	1,130	7,329	9,170
1998	683	972	8,967	10,622
1999	10,811	1,699	8,434	20,944
2000	2,697	5,900	8,818	17,415
2001	366	4,993	13,305	18,664
2002	299	3,906	3,721	7,926

Data Source: DNR Planning and Tracking database

Area fertilized includes both application of biosolids and aerial fertilizer application in North Puget and South Puget Planning Units. Area fertilized updated from e-mail communication from Carol Thayer, 7/24/03.

conditions and the effects anticipated in the Habitat Conservation Plan Environmental Impact Statement.

Mass Wasting

There are no anticipated changes to the risk of mass wasting frequency or severity under any of the Alternatives because no policy or procedural changes would occur under any of the Alternatives with respect to potentially unstable slopes. However, continued careful planning is necessary for all Alternatives, as discussed in Appendix C. Specifically, Alternatives 6 and 5, with the highest levels of management activity as measured by total acreage treated, would be expected to require the greatest amount of additional planning related to potentially unstable slopes, followed by Alternatives 3, 2, 1, and 4.

Surface Erosion

Surface erosion affects soil productivity by removing soil mass, including minerals and organic matter. Surface erosion potentially may be caused by, or accelerated by, forest management. Rates of sediment delivery to streams from timber haul or public use of unpaved roads is correlated to traffic volume and the location of the road relative to streams (USDA Forest Service 2001). Road use is assumed to be a function of the amount of timber extracted on the land. Impacts from public road use are expected to be constant for all Alternatives. Higher levels of forest management can be assumed to require more truck trips and, therefore, potentially increase surface erosion caused by road use. Specifically, Alternatives 6 and 5, with the highest levels of management intensity by total acreage, would be expected to require more planning and maintenance to appropriately address surface erosion, followed by Alternatives 3, 2, 1, and 4. Sediment delivery to streams is discussed in Section 4.7 (Hydrology), Section 4.8 (Water Quality), and Section 4.10 (Fish).



Soil Productivity

The goal of successful sustainable forest management is to meet conservation objectives and fiduciary responsibilities without degradation of soil. Intergeneration equity requires actions that protect and maintain current and future forest functions (Burger and Kelting 1998). For this reason, soil conservation and maintenance or improvement of soil productivity should be inherent qualities of sustainable forest management. Also, based on how harvests are prioritized and calculated, less productive stands should have longer rotation ages than more productive stands. Therefore, if site productivity declines, a longer minimum regeneration harvest age would be needed for the stand in the future. This means that if site productivity declines as a result of degraded soils, longer rotations would be required in the future, and the risk of not meeting harvest goals increases. This is discussed in more detail in Section 4.15 (Cumulative Effects).

Factors that may influence soil productivity among the Alternatives are average minimum regeneration harvest age, management strategies, and management intensity. See Appendix C and Chapter 2 for a description of the variations in these parameters among Alternatives. In general, more intensive management may lead to a greater risk of soil compaction in the short term, or to surface erosion. Specifically, Alternatives 6 and 5, with the highest levels of management intensity by total acreage, would be expected to have the highest risk of potentially decreasing soil productivity, followed by Alternatives 3, 2, 1, and 4. However, the increased use of fertilizers for Alternatives 5 and 6 may mitigate potential losses of productivity due to increased management intensity. When designing and implementing harvest activities on highly compactable soils, locations of skid trails should be carefully planned, and appropriate yarding techniques should be used to prevent or minimize compaction. These are also discussed in more detail in the Cumulative Effects section (Section 4.15).



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4.7 HYDROLOGY

4.7.1 Summary of Effects

This section analyzes the environmental effects on hydrology. The analysis examines the potential effects of proposed changes to policy and procedures and uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

None of the Alternatives would be expected to increase peak flows significantly. No changes to Procedure 14-004-060 (Assessing Hydrologic Maturity) are proposed; therefore, there would be no significant adverse environmental impacts beyond existing conditions and the effects anticipated in the Habitat Conservation Plan Environmental Impact Statement.

4.7.2 Introduction

The hydrology of a watershed includes the amount, intensity, and timing of water movement. Watershed hydrology is affected by climate, vegetation, other physical and biological factors, and watershed management. Changes in peak flows can affect stream bank stability and channel morphology, water quality, salmonid habitat, sensitive plant species, and the built environment (via flooding). Peak flows, which can become large floods, can adversely affect public safety and infrastructure.

During scoping, the main issue for hydrologic resources was identified as peak flows. Forest management can affect runoff and subsurface stormflow, and therefore change the timing and magnitude of peak flows through timber harvest and road construction (Section 3.3 of the Forest Practices Rules Environmental Impact Statement, pages 3-27 through 3-33 [Washington Forest Practices Board 2001] and Section 4.8 of the Habitat Conservation Plan Environmental Impact Statement, pages 4-509 through 4-524 [DNR 1996]). The amount and location of roads and timber harvest can affect the timing and quantity of runoff, subsurface stormflow, and peak flows. Soil compaction, such as may result from the operation of heavy machinery on some soil types, can reduce soil permeability, thereby contributing to peak surface water flows.

4.7.3 Affected Environment

Much of the information presented in this section is drawn from the Draft and Final Habitat Conservation Plan Environmental Impact Statement (pages 4-139 through 4-180, 4-243 through 4-305, 4-509 through 4-524, and Glossary page 6 [DNR 1996] and the Forest Practices Rules Environmental Impact Statement (pages 3-27 through 3-33, Washington Forest Practices Board 2001). Refer to these documents for additional information related to hydrological effects on the environment.

The principal influences on surface water movement are climate, soils, geology, topography, and vegetation (Section 3.3 of the Forest Practices Rules Environmental



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Impact Statement, pages 3-27 through 3-33 [Washington Forest Practices Board 2001]). Precipitation is controlled by climate and is not significantly influenced by forests or their management. Loss of water to the atmosphere by evaporation and transpiration of plants can be influenced by forest management. Water movement in natural streams is a function of water volume, channel geometry, and channel slope or gradient. In unmanaged forest areas, the most common disturbance to stream hydrology is trees and other vegetation entering streams. In places where this debris is temporarily stabilized, flows may back up and increase in depth.

4.7.3.1 Existing Conditions on Western Washington DNR Westside Trust Lands

For the purposes of this analysis, water Types 1 through 4 were identified. Stream types were updated for the model to better estimate the amount of fish-bearing streams on the westside trust lands based on DNR field foresters' reports and other known studies (Bahls and Erath 1994, DNR 1995, Mobbs and Jones 1995). All waters originally mapped as Type 5 and all streams of unknown classification (Type 9) were grouped into Type 4. All Type 4 streams were reclassified as Type 3 streams. Streams originally classified as Type 1, 2, and 3 were kept in their respective categories. As a result, stream miles by type (as displayed in Table 4.7-1) do not match those referenced in the Habitat Conservation Plan Environmental Impact Statement (DNR 1996, page 4-250).

Based on this water typing system, nearly 70 percent of streams in western Washington are classified as non-fish-bearing, Type 4 streams (Table 4.7-1). Relatively few are rated high quality for beneficial uses. Approximately 5 percent of streams in the region are classified as Type 1 or 2. Less than 30 percent are Type 3 streams.

Table 4.7-1. Lengths of Streams on Forested DNR Westside Trust Lands by Stream Type and Planning Unit

Planning Unit	Length of Streams (miles)				Total
	Type 1	Type 2	Type 3	Type 4	
Columbia	101	7	715	2,519	3,343
North Puget	154	52	1,144	1,744	3,093
Olympic Experimental State Forest	156	55	816	1,772	2,799
South Coast	78	25	711	2,102	2,915
South Puget	41	14	271	845	1,171
Straits	21	17	210	383	631
Total	551	170	3,867	9,364	13,952

Data Source: DNR hydro layer data

The largest peak flows in western Washington occur after rain-on-snow events (rainstorms that partially or completely melt snowpacks). The rain-on-snow zone is an area (generally defined as an elevation zone) where rain-on-snow events occur several times during the winter, typically at elevations of 1,000 to 3,000 feet above sea level. During rain-on-snow

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events, rainfall saturates existing snowpacks and causes rapid melting, leading to large volumes of runoff during relatively short periods of time. See Section 3.3 of Forest Practices Rules Environmental Impact Statement (Washington Forest Practices Board 2001).

These events reach their greatest magnitude on forested lands in hydrologically immature forests (i.e., young trees), where the lack of a dense canopy allows greater snow accumulation and subsequent rapid melting (Washington Forest Practices Board 2001, Section 3.3, pages 3-29 through 31). In contrast, hydrologically mature stands approach the hydrologic processes and outputs (e.g., water yield, peak flows) expected in a mature stand under the same climatic and site conditions. Hydrologically mature forests are defined in the Habitat Conservation Plan as well-stocked conifer stands at 25 years or older (DNR 1996, Glossary, page 6). Snow accumulation and rate of melt are generally slower in hydrologically mature forests.

Hydrologically immature forests within significant rain-on-snow/sub-basin zones (i.e., those areas managed for rain-on-snow according to DNR Procedure 14-004-060) cover approximately 20 percent of the forested DNR-managed westside trust lands (Table 4.7-2). The data presented in Table 4.7.2 provide a general characterization of the current hydrologic maturity of the forested DNR-managed westside trust lands. In addition, rain-on-snow zones in many of these watersheds also include land classified as non-forested. Peak flows have the potential to be greater in non-forested areas than in forested areas in rain-on snow zones.

Table 4.7-2. Areas of Hydrologic Maturity and Immaturity in Significant Rain-on-Snow/Sub-basin Zones by Westside Planning Unit (Current 2004)

Planning Unit	Hydrologically Mature Forest in Rain-on-Snow Zones		Hydrologically Immature Forest in Rain-on-Snow Zones		Total Forest in Rain-on-Snow Zones (Acres)
	Acres	Percent	Acres	Percent	
Columbia	56,979	77	16,849	23	73,828
North Puget	62,541	84	11,685	16	74,226
OESF ^{1/}	20,988	58	15,205	42	36,193
South Coast	6,257	98	125	2	6,382
South Puget	36,710	86	5,734	14	42,444
Straits	2,998	97	87	3	3,084
Total	186,474	79	49,684	21	236,157

Data Source: DNR GIS overlay data

^{1/} OESF = Olympic Experimental State Forest

Section 4.15, Cumulative Effects, provides additional information on the status of hydrologic maturity and on the sensitivity of the Alternatives, organized by individual watersheds.



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4.7.4 Environmental Effects

4.7.4.1 Comparison of Alternatives

Procedure 14-004-060, which prohibits harvest of hydrologically mature forest in rain-on-snow and snow zones where the mature forest type makes up less than 66 percent of these zones, would not change under any of the Alternatives. Consequently, significant changes in peak flows due to harvest activities would continue to be avoided under all of the Alternatives. The Habitat Conservation Plan Environmental Impact Statement (DNR 1996) provides more detailed analyses of the effectiveness of the measures laid out in Procedure 14-004-060 and other procedures in minimizing potential adverse effects to peak flows from harvest activities (see Sections 4.2.3, 4.4.2, and 4.8, pages 4-139 through 4-180, 4-243 through 4-305, and 4-509 through 4-524). For this analysis, new road construction is assumed to be similar under all Alternatives. Consequently, the impacts from the road network would be essentially the same under all Alternatives. The potential for any of the Alternatives to result in significant adverse impacts to peak flows, therefore, would most likely result from soil compaction associated with timber harvest activities in riparian areas.

Under Alternative 1 (No Action), timber harvest would not be allowed in riparian areas except for access development (i.e., roads and yarding corridors). Therefore, no change in peak flows would be expected under this Alternative.

The impacts of Alternatives 2 and 3 with respect to changes in riparian procedures would be minor and would not affect peak flows. Over the long term, harvest in the middle and outer zones would result in more diverse stand conditions, which may mitigate potential peak flows.

Alternative 4 would not change the restrictions on allowable activities in Riparian Management Zones. No additional impact on peak flows would be anticipated under Alternative 4, compared to Alternative 1 (No Action).

Alternative 5 would allow more harvest in Riparian Management Zones than Alternatives 1, 2, 3, or 4. If ground-based yarding were implemented in these riparian areas, small areas within the Riparian Management Zones would be compacted, resulting in relatively small, highly localized, short-term increases in peak flows. Given the dynamic nature of hydrologic regimes, these changes to peak flows would not likely be detectable at a watershed scale.

Alternative 6 would allow more harvest in riparian areas than the other Alternatives. Depending on yarding methods, this Alternative could affect localized peak flows. Yarding systems that suspend logs, such as helicopter and cable with full suspension, would not cause soil compaction, and would therefore not affect peak flows. However, if ground-based yarding were implemented at the proposed rate, sufficient soil compaction may occur in some areas to cause localized increases in peak flows. Similar to Alternative 5, short-term localized increases would not likely be detectable at the watershed scale.



4.8 WATER QUALITY

4.8.1 Summary of Effects

This section analyzes the environmental effects on water quality. The analysis examines the current policy and procedures and the prospective changes. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts of the Alternatives. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

The proposed different management strategies would not result in any probable significant adverse impacts beyond existing conditions and the effects anticipated in the Habitat Conservation Plan Environmental Impact Statement. None of the Alternatives would increase the risk of water quality degradation in the long term. Existing procedures adequately protect water resources. Short-term, localized sedimentation may increase in some areas immediately following harvest, but the vegetation in the inner and no-harvest portion of the Riparian Management Zones would prevent most sediment from entering streams. Over the long term, improved riparian function would likely lead to improved water quality on DNR-managed westside trust lands.

4.8.2 Introduction

Water quality is a function of several variables, including sediment input, organic input, hydrology, levels of contaminants (including forest chemicals such as pesticides, herbicides, and fertilizers), and temperature. Each of these variables is dependent upon several factors, including local weather and climate, stream morphology, sources of erosion, levels of chemical use and pathways for migration of contaminants, filtering and binding capacity for contaminants of vegetation and organic material, and amounts and types of vegetation near streams.

Streams at lower elevations are likely to have higher temperatures than streams at high elevations. However, groundwater discharge may regulate temperature in smaller streams. Shading provided by vegetation helps maintain low water temperatures. Stream temperature may rise as a result of timber harvest in areas adjacent to streams due to effects of increased solar radiation. The link between stream temperature and upslope clearcuts is less certain. Finally, vegetation in riparian areas and in the watershed in general can reduce sediment input and overland flow of water, reducing peak flows, as discussed in Section 4.7, Hydrology. See also Section 3.6 of the Forest Practices Rules Final Environmental Impact Statement (Washington Forest Practices Board 2001),

Good water quality enables beneficial uses, such as fish habitat and recreation. The main issue identified for water quality during scoping was the potential adverse effects to water quality caused by forest management activities. Specifically, increases in stream water temperature and sediment delivery to streams and the introduction of forest chemicals



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(i.e., pesticides, herbicides, and fertilizers) to the aquatic environment were identified as key issues. Changes to these parameters can affect aquatic habitat, recreation, and other beneficial uses.

4.8.3 Affected Environment

This section draws on the discussion in the Habitat Conservation Plan Environmental Impact Statement (DNR 1996) and Forest Practices Rules Environmental Impact Statement (Washington Forest Practices Board 2001) to describe the regulatory background and water quality conditions in western Washington. Refer to these documents for additional information related to water quality effects on the environment.

Temperature

Surface water temperature plays an integral role in the biological productivity of streams. Section 3.6 of the Forest Practices Rules Environmental Impact Statement (Washington Forest Practices Board 2001) describes how the temperature of surface water is modified by forest management. Streamside vegetation prevents extreme daily fluctuation in temperature during low flows and high solar energy input by providing shade and absorbing energy. Dissolved oxygen concentrations are higher with lower temperatures, which benefits many aquatic biota. Low stream temperatures are critical for the survival of various fish species. When changes in water temperature occur as a result of timber harvesting, they are typically noted in small rivers and streams.

Sediment

Sedimentation accounts for significant water quality deterioration in forested lands in the state of Washington (Section 4.8, page 4-509, Habitat Conservation Plan Environmental Impact Statement [DNR 1996]). Sediment affects water quality in several ways. It creates a muddy (turbid) condition that restricts light in the stream environment. Nutrients combined with, or attached to, the sediment particles are added to surface water. Oxygen-demanding materials associated with sediment can reduce dissolved oxygen content. Sedimentation may also introduce harmful minerals and chemicals into surface water. Biological effects of increased turbidity may include a decrease in primary productivity of algae and periphyton because of decreased light penetration. Declines in primary productivity can adversely affect the productivity of higher trophic levels such as macroinvertebrates and fish. Siltation and turbidity have also been shown to affect fish adversely at every stage in their life cycle.

The amount of sediment that reaches a stream depends primarily on two processes: the availability of sediment and the ability of sediment to travel from its source to the stream. Sediment is produced through mass wasting and surface erosion, as described in Section 4.6, Geomorphology, Soils, and Sediment, and in Section 4.15, Cumulative Effects.

The ability of sediment to travel from its source to streams could be affected through changes in harvest in riparian areas. In general, the vegetation in riparian areas serves as a filter, removing sediment before it reaches a water body. In most cases, vegetation immediately adjacent to a stream channel is most important in maintaining bank integrity



(Forest Ecosystem Management Assessment Team 1993). Protection of stream bank integrity and adequate soil filtering of surface erosion is generally maintained with a fully functioning stand within 30 feet of a stream.

Forest Chemicals

Chemicals used in forest management include a variety of herbicides, fertilizers, and pesticides introduced to the forest environment to control or halt the proliferation of nuisance organisms or to improve soil productivity. Fertilizers used between 1993 and 2002 in the region include urea (aerial applications) and biosolids (ground applications). The following herbicides were also applied (aerially and by ground application): 2,4-D Ester, Accord, Arsenal, Garlon 4, Oust, Roundup, Transline, and Velpar L. Chemicals used in the forest environment can become water contaminants if they are transported to surface waters (or groundwater). They can also be directly applied to surface waters by overspray and spills. Contamination usually results from the lack of spray buffers or from applications over dry or ephemeral streams.

According to DNR records, between 1993 and 2002, herbicides were applied to approximately 70,000 acres within DNR-managed westside trust lands (Table 4.8-1). Ground applications of herbicides were applied in every planning unit, while aerial applications occurred in all areas except the Olympic Experimental State Forest and the Straits Planning Unit. Fertilization applications were less common, with aerial fertilization occurring only in the North Puget Planning Unit. Ground fertilization occurred only in the North Puget Planning Unit and, to a very limited extent, in the South Puget Planning Unit (less than 100 acres).

Pesticide application rates on forested lands were infrequent (one to two applications every 40 to 60 years). Less than 5 percent of DNR westside trust lands have been treated with chemicals during the last decade. This 10-year application history suggests that herbicides are the most common forest chemicals applied in the westside trust lands. These relative levels of use are likely to continue into the future.

Several monitoring studies designed to evaluate the effects to water quality from fertilization applications in western Washington and similar nearby forested lands have been conducted (Bisson 1988, Cline 1973, Moore 1974, McCall 1970, Ryan 1984, Ryan and Donda 1989). In general, the results of these studies show that significant short-term increases of urea, ammonia, nitrate, nitrite, and phosphorus typically following applications of urea and phosphorus-rich fertilizer. However, none of these studies found concentrations that exceeded water quality standards. Likewise, accelerated eutrophication (water pollution caused by excessive plant nutrients), which can lead to oxygen depletion, was not detected. Similarly, concentrations generally returned to pre-fertilization levels within 40 days (McCall 1970, Ryan and Donda 1989). Relatively large, localized increases were attributed to aerial fertilizer applications directly into tributary streams (Ryan 1984, Bisson 1988). Large precipitation events are correlated with increased nitrates measured in streams, caused by flushing of forested soils and delivery of chemicals to streams in storm runoff (Perrin 1976).



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Table 4.8-1. Extent of Fertilization (Aerial and Ground) and Herbicide Application (Aerial and Ground) by Year in Forested DNR Westside Trust Lands

Year Completed	Area of Aerial Fertilization (Acres)	Area of Aerial Herbicides (Acres)	Area of Ground Fertilization (Acres)	Area of Ground Herbicides (Acres)	Total Area Treated (Acres)
1993	<1	1,449	<1	5,766	7,215
1994	<1	685	<1	1,491	2,176
1995	<1	1,436	<1	3,041	4,478
1996	<1	1,096	368	2,864	4,328
1997	20	2,874	381	2,926	6,201
1998	82	2,778	278	4,586	7,724
1999	2,888	3,882	456	2,946	10,172
2000	2,405	4,384	186	2,627	9,602
2001	<1	6,062	366	4,126	10,554
2002	<1	2,483	299	1,838	4,620
Total	5,396	27,130	2,334	32,211	67,070

Source: DNR Planning and Tracking database and e-mail communication from Carol Thayer, 7/24/03. Fertilization occurred in North Puget and South Puget planning units.

Contaminants, such as fertilizers or herbicides that reach forest streams, can be flushed into larger water bodies. Some of these contaminants may be broken down by natural processes, such as ultraviolet radiation or digestion by organisms. In general, sufficient levels of increased nutrients can cause algae blooms in lakes and stagnant water bodies, causing eutrophication and resulting decreases in dissolved oxygen, potentially harming fish. Dissolved oxygen levels are further addressed with respect to DNR westside trust lands in Section 4.10 (Fish) and Section 4.15 (Cumulative Effects).

Groundwater

Groundwater includes all water below the ground surface. Groundwater is not as sensitive to water quality degradation from forest management as surface water. In general, the quality of groundwater in aquifers depends more on aquifer and local geology than on forest influences. Activities in forest watersheds can affect groundwater quality, if they cover a large proportion of the watershed, and depending on the type and timing of the activity. See Section 4.8 of the Habitat Conservation Plan Environmental Impact Statement (DNR 1996) and Section 3.6 of the Forest Practices Rules Environmental Impact Statement (Washington Forest Practices Board 2001).

Subsurface flows, an important component of groundwater, are sensitive to immediate precipitation. Applying forest chemicals, for example, immediately prior to a rainstorm would increase the probability of degrading groundwater quality, if a sufficient portion of the watershed were treated. Groundwater contamination by forest chemicals can also occur through contaminated surface water recharge. As a result of the natural soil filters, groundwater recharged from forest land is generally of good quality.



4.8.3.2 Existing Water Quality

The Washington State Forest Practices Rules comply with the Clean Water Act to meet state water quality standards for surface waters and groundwater (Table 4.8-2). Water quality standards are set to provide for the protection of designated uses, including public water supply, wildlife habitat, and salmon spawning, rearing, and migration.

Table 4.8-2. Washington State Water Quality Standards for the Major Non-Chemical Parameters of Concern^{1/}

Water Quality Parameter	Washington State Standard (Class AA, Excellent)	Washington State Standard (Class A, Good)
Temperature	Shall not exceed 16.0°C due to human activities. When natural conditions exceed 16°C, no temperature increase greater than 0.3°C is allowed. Incremental temperature changes from nonpoint source activities shall not exceed 2.8°C.	Shall not exceed 18.0°C due to human activities. When natural conditions exceed 18°C, no temperature increase greater than 0.3°C is allowed. Incremental temperature changes from nonpoint source activities shall not exceed 2.8°C.
Sediment	In regard to forest practices, implementation of approved best management practices will meet narrative water quality criteria such as support characteristic water uses, aesthetic values, etc.	Same as Class AA.
Turbidity ^{2/}	Shall not exceed 5 NTUs (nephelometric turbidity units) over background when the background level is 50 NTUs or less, nor increase more than 10% of background when the background level is 50 NTUs or more.	Same as Class AA.

1/ New water quality standards have been proposed and are currently in a draft status. The new standards for temperature would be lower and more specific to fish populations (Department of Ecology 2003).

2/ Nephelometric turbidity units are the measurement units of turbidity using a nephelometer (light reflected surfaces of particles in suspension that are at right angles to the light source). 0 NTUs is clear and free of particles. >999 NTUs is essentially opaque.

NTU = nephelometric turbidity unit

Data Source: Forest Practices Rules Environmental Impact Statement (Washington Forest Practices Board 2001)

Section 303(d) of the federal Clean Water Act requires the state of Washington periodically to prepare a list of all surface waters in the state for which beneficial uses of the water are impaired by pollutants. As of 1998, about 2 percent of all the waters in Washington were identified as impaired. Segments of almost 250 streams were listed in western Washington in 1998 (see Appendix D). It is possible that other unmeasured water bodies also exceed water quality standards.

As stated in Section 4.8, page 4-509 of the Habitat Conservation Plan Environmental Impact Statement (DNR 1996), in general, the forests in western Washington contain waters of high quality. The primary water quality problem on forestlands throughout the state is temperature. Elevated water temperature generally occurs in areas where timber



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harvest or development has removed trees adjacent to rivers and streams, taking away shade, which is necessary to keep the water temperature low and healthy for fish. Other problems include erosion from road building, construction, and agriculture, which increases sediment in streams (Forest Practices Rules Final Environmental Impact Statement, Section 3.6, page 3-106). A discussion of temperature and water quality problems on DNR-managed lands is also included in Section 4.15 (Cumulative Effects).

4.8.4 Environmental Effects

4.8.4.1 Comparison of Alternatives

Temperature

Stream temperature can be affected by the amount of shade provided by streamside vegetation. The Alternatives differ with respect to the level of harvest within the Riparian Management Zones. Refer to Section 4.3.3 (Riparian Environmental Effects) for details on the potential effects of the proposed Alternatives on stream shading. As described in that section, shade levels would generally improve under all Alternatives because all Alternatives would have a 25-foot no-harvest buffer, and would allow less harvest in the remainder of the Riparian Management Zone than allowed prior to implementation of the Habitat Conservation Plan riparian strategies. More large trees would develop (at differing amounts) under all Alternatives compared with current conditions. Improved shade levels would result in decreased stream temperatures, which would benefit most aquatic biota in these streams.

Differences among the Alternatives in the amount of harvest allowed in Riparian Management Zones would lead to variations in anticipated effects on stream temperature. Relative to Alternative 1, some short-term reduction in shade may result from the removal of riparian trees under Alternatives 2, 3, 5, and 6.

Sediment

Mass wasting is not expected to increase as a result of implementation of any of the Alternatives; however, increased harvest would increase the risk of surface erosion from road use and other harvest-related activities. Other than restoration activities, roads, and yarding corridors, none of the Alternatives proposes activities within the 25-foot No Harvest Zone. The adjoining 75 feet is the Minimal Harvest Zone that would include restricted activities that vary among Alternatives. This level of Riparian Management Zone protection reduces the differences in sediment delivery among Alternatives. Under Alternatives 1 and 4, the current riparian procedures would continue to be implemented and only riparian and stream restoration work and access development (roads and yarding corridors) would be allowed in Riparian Management Zones. These Alternatives would result in the same levels of sediment production described under current conditions and would not affect the filtering capacity of the Riparian Management Zone.

Alternatives 2 and 3 would allow more harvest in Riparian Management Zones and upland areas than Alternatives 1 and 4. The additional harvest in Alternatives 2 and 3 may lead to



minor, localized increases in sediment caused by ground-based logging or, to a lesser extent, cable yarding and other ground disturbances. The increase in associated activities, such as road travel, could also contribute to the potential for increases in surface erosion. Surface erosion would be mitigated through the implementation of appropriate practices under these Alternatives. As a result, sediment production would not be significantly different from Alternatives 1 and 4.

Alternatives 5 and 6 would involve increased management and, therefore, increased risk of surface erosion compared to Alternatives 1, 2, 3, and 4. The additional harvest in Alternatives 5 and 6 may lead to minor, localized increases in sediment. Additionally, the increase in associated activities could also contribute to the potential for increases in surface erosion. The surface erosion would be mitigated through the implementation of appropriate policies and procedures under these Alternatives. The impacts that Alternatives 5 and 6 would have on sediment delivery would likely be relatively minor as long as the no-harvest inner zone remains in place to filter sediment.

The potential for blowdown in Riparian Management Zones would be slightly greater under Alternatives 5 and 6 than under the other Alternatives because of the increased level of thinning. If blowdown occurs, root balls could be dislodged, leading to increased sediment. Potential adverse effects from increased harvest levels would be mitigated by using appropriate harvest and regeneration methods to prevent surface erosion, and the no harvest zone vegetation would remain in place to filter sediment before it reached a stream. However, openings greater than 1 acre increase the risk of blowdown, which could affect the inner zone (Carey et al. 1996).

Additional planning and implementation resources would be required to prevent sediment delivery to streams as a function of greater harvest in the Riparian Management Zones under Alternatives 2 and 3, and, to a greater extent, under Alternatives 5 and 6.

Forest Chemicals

Fertilization levels would also differ under the Alternatives (Table 4.8-3). Alternatives 1, 2, 3, and 4, would include little to no fertilization. Alternative 5 would involve increased management intensity and would include fertilization treatments. Alternative 6 would include fertilization, but less frequently than under Alternative 5. Despite the relative differences in fertilization, these Alternatives would be consistent with existing forest policies and procedures, described in the Habitat Conservation Plan and Forest Practices Rules Environmental Impact Statement.

Table 4.8-3. Fertilization Intensity by Alternative

Approach to Fertilization	Alternatives					
	1	2	3	4	5	6
Little or none	X	X	X	X		
Available for specific forest types and sites					X	
Budget-limited for specific forest types and sites						X



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These policies and related mitigation measures were established, in part, to protect water quality. For example, mitigation measures exist to reduce the likelihood of accidental aerial applications directly to streams, the leading cause of water quality degradation from forest chemicals (see Appendix C for a discussion of policies and procedures). As a result, none of the Alternatives would likely result in significant adverse affects to water quality caused by forest chemicals.



4.9 WETLANDS

4.9.1 Summary of Effects

This section analyzes the environmental effects on wetland resources. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

DNR Forest Resource Plan Policy No. 21 states, “the Department will allow no overall net loss of naturally occurring wetland acreage and function.” The supporting procedure governs harvest activities in and around wetlands and is not proposed to change in any of the Alternatives.

The approximate delineation method, an approved approach to determine wetland boundaries, primarily uses maps and aerial photographs. However, not all wetlands, particularly forested wetlands, are visible on aerial photographs. The Habitat Conservation Plan and its Environmental Impact Statement acknowledge that wetlands less than 0.25 acre may be affected by forest management activities.

The higher levels of harvest in Alternatives 5 and 6 would increase the relative potential risk to wetlands, but no Alternative has the potential for significant adverse environmental impacts.

4.9.2 Introduction

Wetlands are defined as those “areas that are inundated or saturated with surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions” (Washington Administrative Code 222-16-010, Code of Federal Regulations 230.41a (1), U.S. Army Corps of Engineers Experimental Laboratory 1987). Wetlands are generally valued for the hydrologic, biogeochemical, and habitat functions that they perform. The primary environmental issue that relates to wetlands is the potential loss of wetland area or functions on DNR-managed trust lands due to forest management activities, including timber harvest and road construction.

4.9.3 Affected Environment

The policies and regulations that govern the management of wetlands on forested trust lands can be found in Appendix C.

4.9.3.1 Wetlands in DNR-managed Westside Trust Lands

Two sources of Geographic Information System data were used to identify acres of wetland in DNR trust lands. The first source is FPWET, a DNR layer derived from National Wetlands Inventory data. National Wetlands Inventory, of the U.S. Fish and Wildlife Service, produces information on the characteristics, extent, and status of the nation’s wetlands and deepwater habitats. The wetland maps are based on stereoscopic analysis of aerial photographs and are useful in identifying the general location and extent



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of wetlands. However, this wetland inventory is not based on site visits. National Wetlands Inventory is generally thought to underestimate the extent of forested wetlands.

The second data source is from the DNR Forest Resource Inventory System. The land types of the areas reviewed were identified photographically by DNR foresters and had various levels of field review. Because the review was based primarily on photographic interpretation, it could also underestimate the extent of forested and small wetlands. Both data sources were used to identify the extent of wetlands mapped in DNR westside trust lands. Where there was a conflict between the two layers regarding wetland type, the DNR Forest Resource Inventory System was used to determine the wetland status.

Approximately 1.5 percent of the land in DNR-managed westside trust lands is mapped as wetland. Of that, 44 percent is mapped as forested and 56 percent is mapped as non-forested. As discussed above, the actual acres of wetland may be higher because the identification was done primarily by using aerial photographs.

The six planning units range between 0.7 and 2.5 percent wetland (Columbia – 0.7 percent, North Puget – 1.2 percent, Olympic Experimental State Forest – 1.4 percent, South Coast – 2.5 percent, South Puget – 1.7 percent, and Straits – 1.9 percent).

4.9.3.2 Wetland Functions

Wetlands are ecologically important because of functions related to water quality, floodwater retention, ground water recharge, and habitat for many kinds of organisms:

- **Hydrologic functions**, including discharge of water to downstream systems, low-flow augmentation and flood-peak attenuation, surface and subsurface water storage, water dissipation through transpiration, and sediment retention.
Benefits: stabilization of stream flow, floodwater attenuation, improved water quality.
- **Biogeochemical functions**, including organic carbon production and export, cycling of elements and compounds, and maintenance of conditions, including soils that support diverse plant communities.
Benefits: food chain support, toxicant and nutrient recycling, natural waste treatment, substrate for habitat diversity.
- **Habitat functions**, including maintenance of characteristic habitat structures, habitat interspersions and connectivity, and vegetative community composition.
Benefits: Essential habitat for amphibians and aquatic invertebrates, utilization for nesting and feeding by numerous bird and mammal species, food web support, human aesthetic enjoyment, connectivity for wildlife movement, and refugia during environmental fluctuations.

Timber harvest activities in or around wetlands may result in loss of wetland area and wetland function.



4.9.4 Environmental Effects

The Alternatives considered in this analysis do not propose to change any policies or procedures for managing forested wetlands, non-forested wetlands, or Wetland Management Zones. In all Alternatives, harvest and harvest-related activities would occur in forested wetlands outside Riparian Management Zones, and light access development and maintenance would be allowed in the Wetland Management Zones when necessary. However, differences between Alternatives in policies and procedures for managing Riparian Management Zones would affect the forested wetlands within the Riparian Management Zone boundaries.

Potential effects to wetland functions are discussed below. Functions vary considerably among wetlands, and functions and impacts might not affect every wetland. Also, there is limited data available on wetland hydrology or the impacts of harvest on wetlands, specifically in the Pacific Northwest. Most of the studies available have been done in other parts of the country, and generalization to harvest in the Pacific Northwest should be done with caution. Brief descriptions are provided for the impacts to wetland functions; more detail is available in Habitat Conservation Plan Environmental Impact Statement (DNR 1996).

4.9.4.1 Direct Effects

Forested Wetlands

Tree harvesting, especially clearcutting, in wetland sites can alter wetland hydrology and raise the elevation of the water table. Timber harvest has also been found to increase the range of week-to-week water level fluctuations (Veery 1997).

Changes in hydrologic patterns of wetland sites can directly influence plant species and growth within the wetland site. Excessive water in the substrate stops root growth and microbial activity, and can lead to unfavorable biochemical activity (Veery 1997). As discussed in the Habitat Conservation Plan Environmental Impact Statement (DNR 1996), wetlands provide important habitat for plants and receive disproportionately high use by wildlife. Changes in vegetation and substrate can have positive or negative impacts on specific species.

The altered water table and associated streamflow relationship, over large areas, could increase localized runoff and flooding. These effects can be short term, and cease once a site becomes revegetated with emergent, shrub, or forest vegetation (Grigal and Brooks 1997). In some cases, an elevated water table resulting from timber harvest in a forested wetland could preclude the re-establishment of trees in the long term. Because there is little data on forested wetland hydrological response to timber harvest in the Pacific Northwest, this represents an unknown risk. An inability to regenerate trees would be considered a loss of function in a forested wetland. As discussed in the Habitat Conservation Plan Environmental Impact Statement (DNR 1996), wetlands perform an important function in augmenting streamflow during low flow periods and in moderating flows during storm events.



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Water quality of wetland sites can be measurably affected by harvest activities, although effects can be transient depending on the activities (Shepard 1994). Harvest and associated activities (road building and use) can deliver sediment to wetlands, diminish water quality, and lead to the filling of wetland sites. Nutrient pathways within wetlands can also be affected. Nutrients are removed directly from wetlands during harvest, and increases in export of nutrients can occur after harvesting.

The timing and method used to extract products from the forest can significantly influence effects on wetlands. Heavy equipment use in wetlands usually has concentrated impacts in specific areas that can alter soil properties locally. Additionally, soil rutting and compaction from timber harvest activities can reduce infiltration, redirect flow, and alter pathways by which water moves through and from wetlands (Grigal and Brooks 1997).

Tree harvesting and associated activities can also affect wetland sites and adjacent or nearby land by potentially altering hydrology; changing nutrient pathways; delivering sediment (which can diminish water quality); changing species composition, growth, and structure; and reducing shading. These factors could result in some loss in wetland functions. While the hydrologic and biogeochemical functions begin to return as soon as tree revegetation occurs, habitat functions can require more time and forest regrowth to return.

The Forest Resource Plan policies and Habitat Conservation Plan strategies were developed to reduce the potential effects of harvest to forested wetland functions. Maintaining and perpetuating a windfirm stand with a minimum basal area of 120 square feet per acre should maintain at least 95 percent of the evapotranspiration and prevent large changes to hydrology (DNR 1996). Retaining these trees would also reduce the loss of habitat. Minimizing disturbance as directed in the Forest Resource Plan and Habitat Conservation Plan reduces potential impacts to water quality and other functions through reduction of sedimentation and retention of soil conditions and cycling of nutrients. Thus, timber harvest impacts to forested wetlands are reduced while still allowing DNR to meet its other management objectives.

Another potential impact to forested wetlands is related to the wetland inventory done before a harvest. The Forest Practices Rules do not require an on-site survey to delineate all wetlands, but call for approximate determination of the wetland boundaries within the proposed harvest area. Forested wetlands and wetlands smaller than 0.25 acre are difficult to identify through aerial photographs, are not always accurately located on maps, and are sometimes difficult to distinguish on the ground, especially during the dry season. Therefore, a functioning wetland could be misidentified as non-wetland during the planning and/or harvest activities.

While efforts are made to prevent this type of error, a wetland could be harvested as non-wetland. In this case, the wetland would not receive the protection of minimized disturbance as directed in the Forest Practices Rules, Habitat Conservation Plan, and as discussed above. The wetlands would be expected to experience at least short-term loss in wetland area and/or functions. While the hydrologic and biogeochemical functions can



return if there is tree revegetation, the habitat functions can require more time and forest regrowth to return.

Wetland Management Zones (Non-forested Wetlands and their Associated Buffers)

There are no proposed changes in the policies and procedures for Wetland Management Zones. The non-forested wetlands and buffer could experience disturbance, localized clearing, and possibly loss of wetland acreage. The impacts to wetland functions would be similar to impacts discussed above for forested wetlands. If an activity results in the loss of wetland acreage, on-site and in-kind, equal-acreage mitigation would be required.

As with forested wetlands, approximate determination of the wetland boundaries within the proposed harvest area is required for non-forested wetlands. While there is still potential to misidentify non-forested wetlands during this process, it is less likely because they are easier to recognize. If non-forested wetlands are not correctly identified and buffered, they would not receive the protection of Wetland Management Zone designation and would experience the effects described under Forested Wetlands.

Road Construction

Construction of roads can have the greatest direct impact on wetlands because it permanently removes the roaded portion of wetlands, thereby eliminating the associated biological functions and potential for future tree growth. Additionally, crossing wetlands with roads and without adequate provision for cross-drainage can lead to flooding on the upslope side and subtle drainage changes on the downslope side of crossings (Stoeckeler 1967, Boelter and Close 1974).

The Forest Practices Manual requires accurate delineation of wetland boundaries for the portions of any wetland where road construction could result in filling or draining more than 0.1 acre. This would ensure that all potential losses of wetland acreage are identified. Avoidance of wetlands during road planning is a primary method for preventing effects to wetlands. Where the wetlands cannot be avoided, the Forest Resource Plan requires no net loss of wetland acreage or function.

The Forest Resource Plan and Habitat Conservation Plan require on-site and in-kind equal-acreage mitigation for wetland losses. By implementing this mitigation, there should be no significant net effect to the acreage or hydrologic and biochemical function of wetlands in the site. There can be a reduction in habitat for some species by building a road.

4.9.4.2 Indirect Effects

A less obvious impact to wetlands is the indirect impact of harvest in adjacent acreage. Harvest of adjacent acres may affect the water quality and hydrologic functions through increased sedimentation and changes in the local hydrology. Harvest also could have an effect on habitat functions.

The buffers required for DNR-managed forested trust lands and Olympic Experimental State Forest wetlands were selected to protect the wetlands from impacts of forestry activities. In the Forest Practices Rules Final Environmental Impact Statement



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(Washington Forest Practices Board 2001), several references were cited to show that, in general, a buffer width of 100 feet or greater has been found to provide protection from impacts to the water quality and hydrologic functions. Discussions in that document also noted that a larger buffer would be needed to fully protect fish and wildlife habitat functions. The buffers required by the Forest Resource Plan for DNR-managed trust lands are 100 feet or larger. Therefore, harvest effects to hydrologic and biogeochemical functions in non-forested wetlands should be prevented and effects to wetland habitat functions should be minor.

4.9.4.3 Comparison of Alternatives

The potential impacts described above are types of impacts that could result from harvest or harvest-related activities occurring in wetlands. None of the Alternatives proposes any changes in the policies and procedures for management of harvest or harvest activities in wetlands or wetlands buffers. The difference in environmental impacts to wetlands under Alternatives 1 through 6 would be a function of the acreage to be harvested and the amount of related activities.

The first comparison considered is the percentage of riparian and wetland area disturbed in each Alternative. Because wetlands and wetland buffers were not separated from the stream data in the model, the riparian land class is used to compare Alternatives. The riparian land class includes streams, stream buffers, wetlands, and wetland buffers. While this classification includes land that is not wetland, it allows for a relative comparison of activities in areas that are likely to contain wetlands.

The second comparison considered is harvest activity outside riparian areas that may affect wetlands. These two types of areas are upland areas with general management objectives and upland areas with specific management objectives, such as protection of unstable areas and Habitat Conservation Plan-identified species habitat or visual corridors. A higher level of harvest activity in either of these non-riparian areas would be expected to have a higher potential to affect wetlands, through direct harvesting and related activities such as road building. Table 4.9-1 summarizes the average harvest per decade by Alternative by land class.

Activities in the Riparian Land Class

For each Alternative, the amount and type of harvest proposed for riparian areas is different. The impacts to the riparian land class for each Alternative are discussed in detail in Riparian Areas (Section 4.3). Table 4.9-1 provides a summary of the average harvest by decade in the riparian and wetland areas for each Alternative.



Table 4.9-1. Average Percent of Acres in each Land Class Harvested per Decade

Alternative	Percent of Area of Land Class Harvested per Decade			
	Riparian and Wetland Areas (percent)	Uplands with Specific Objectives ^{1/} (percent)	Uplands with General Objectives (percent)	Total All Classes (percent)
1	3	10	25	12
2	7	18	27	17
3	8	18	30	18
4	5	12	29	14
5	13	30	34	26
6	36	27	34	31

DNR source: Model output data – timber flow levels

1/ Includes uplands with protection for unstable areas and Habitat Conservation Plan-identified species habitat, and visual corridors

Activities in the Upland Land Classes

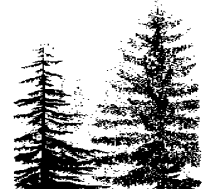
In upland areas with special management objectives, Alternatives 1 and 4 would have the lowest level of activities, with an average of about 10 and 12 percent of acres disturbed per decade. Therefore, Alternatives 1 and 4 would have the lowest potential to affect wetlands. This is followed by Alternatives 3 and 2, each at 18 percent per decade. Alternatives 5 and 6 would have the highest level of harvest-related activities, with an average of 30 and 27 percent of acres disturbed per decade, respectively. Therefore, Alternatives 5 and 6 would have the highest potential to affect wetlands in the upland areas with special management objectives.

In the upland areas with general management objectives, Alternatives 1 and 2 (25 percent and 27 percent disturbance per decade) would have the lowest potential to affect wetlands. This is followed by Alternative 4 at about 29 percent disturbance per decade and Alternative 3 at 30 percent per decade. Alternatives 5 and 6 would have the highest level of activities, each with an average disturbance of about 34 percent of the upland acres per decade. Therefore, Alternatives 5 and 6 would have the highest potential to affect wetlands in the upland areas with general management objectives.



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4.10 FISH

4.10.1 Summary of Effects

This section analyzes the environmental effects on fish. The analysis examines the current policy and procedures and uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

Under the proposed Alternatives, it is expected that fish resources would not have significant adverse effects beyond those anticipated in the Habitat Conservation Plan environmental analysis. In general, the effects would be expected to follow those described in Section 4.3, Riparian Areas. Over the long term, all Alternatives would be expected to result in improved riparian and aquatic conditions for fish. In part, this is the result of current degraded conditions in many areas that resulted from practices prior to the Habitat Conservation Plan.

The potential for adverse effects to fish resources from Alternatives 1 through 4 is expected to be minimal during the first decade in all planning units. In contrast, harvest activities in the riparian zone are expected to occur at higher levels under Alternatives 5 and 6, largely in the form of more frequent thinning activities. In particular, the estimated level of activity under Alternative 6, which would affect an average of 35 percent of the riparian area per decade, represents substantially higher levels than the other Alternatives, although the majority of the harvest area in Alternative 6 would be low-volume removal harvests. As explained in Section 4.3, it appears likely that the modeling outputs for Alternative 6 over-estimates the amount of allowable activity in the riparian areas. The model may overestimate the rate and intensity of harvest activities in riparian areas. Model assumptions will be reviewed for the Final Environmental Impact Statement.

4.10.2 Introduction

Fish species are important natural resources that have ecological, economic, and cultural significance in the state of Washington. Pacific salmon and trout are good indicators of a properly functioning aquatic ecosystem, because they require cool, clean water, complex channel structures and substrates (beds under water bodies), and low levels of fine sediment (Bjornn and Reiser 1991). In addition, Pacific salmon and trout populations have provided for viable commercial and sport fishing industries. During the scoping process for sustainable forestry and associated harvest level, concerns were expressed about how the Alternatives would affect water quality, riparian areas, and aquatic habitat, including aquatic species. There were concerns about the potential effects of road maintenance, possible new road building, and road abandonment.

For the purpose of this project, DNR westside trust lands are estimated to include approximately 13,950 miles of streams. About one-third (4,590 miles) of these streams are



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fish-bearing Type 1 to 3 streams¹. The remaining streams do not support fish, but can influence downstream conditions through the transport of water, nutrients, leaf and needle litter, sediment, and woody debris. Numerous factors affect fish population numbers, which can be highly dynamic. Many of these factors are unrelated to forest practices on DNR-managed lands. Consequently, this analysis focuses on fish habitat rather than population numbers.

The effects analysis presented in Section 4.10.3 relies heavily on analyses presented earlier in this document including:

- Riparian Areas (Section 4.3)
- Geomorphology, Soils, and Sediment (Section 4.6)
- Hydrology (Section 4.7)
- Water Quality (Section 4.8)

The fish effects analysis synthesizes the pertinent components of the above analyses. These sections evaluate the components of the aquatic environment described below in Section 4.10.3 and the major issues developed during the scoping process.

4.10.3 Affected Environment

4.10.3.1 Priority Species

Fish species selected as the focus of this analysis include chinook, sockeye (kokanee), coho, and chum salmon, steelhead (rainbow), coastal cutthroat, and bull and Dolly Varden trout. These species were selected because, with the exception of Dolly Varden trout, they are listed as threatened under the federal Endangered Species Act or are a candidate species (coho salmon). All of the species mentioned have commercial or sport harvest value and are known to be sensitive to forest management activities. See page 3-121 of the Forest Practices Rules Final Environmental Impact Statement (Washington Forest Practices Board 2001) for additional details regarding these species under the Endangered Species Act.

The status of listed salmon species in Washington is currently undergoing re-assessment under the Endangered Species Act. In September 2001, the U.S. District Court in Eugene, Oregon, determined that National Oceanic and Atmospheric Administration Fisheries Service could not split Oregon coast coho salmon into two components, hatchery and wild, and only list one component (wild fish) under the Endangered Species Act. While this decision did not specifically affect any listed salmon other than Oregon coast coho, the decision did prompt the Fisheries Service to re-assess the listing status and critical habitat designations for salmon species throughout much of the Pacific coast.

¹ The current DNR Geographic Information System layer for streams is believed to underestimate the amount of Type 3 streams. Consequently, for the purposes of the sustainable harvest calculations, stream types in the DNR Geographic Information System stream layer were modified by upgrading Type 9 and Type 5 streams to Type 4, and Type 4 streams to Type 3 (see Appendix B).



In addition to these re-assessments, the Fisheries Service is also considering how to treat hatchery populations identified in the Endangered Species Act listing determinations. The draft results of these determinations are expected during late 2003 with final determinations to be published in mid-2004.

Regardless of potential changes in the Endangered Species Act status of these species, it is unlikely that the status of freshwater habitat conditions considered degraded in many westside watersheds has improved substantially since the Fisheries Service Endangered Species Act Status Reviews (NOAA Fisheries 2003a). The Habitat Conservation Plan (DNR 1997) has been in place only since 1997. Consequently, monitoring has not been conducted sufficiently long enough to demonstrate significant improvements in habitat conditions (DNR 2002b). Improvements in ocean conditions during the last few years have resulted in increased adult returns of Pacific Northwest salmon. However, these increases may also be influenced by other conservation efforts in the region (NOAA Fisheries 2003b).

A basic understanding of the life history and habitat requirements of Pacific salmon and trout is important for recognizing the type and level of effects that may result from a land-use activity such as timber harvest. The following represents a brief overview of salmon and trout life history. Additional details of species-specific traits can be found on pages 3-120 through 3-129 in the Forest Practices Rules Final Environmental Impact Statement (Washington Forest Practices Board 2001).

The life cycle of Pacific salmon and trout can be divided into seven distinct phases or lifestages: upstream migration, spawning, egg incubation, fry emergence, juvenile rearing, smolt outmigration, and marine rearing. One commonly recognized variation in life history traits for Pacific salmon and steelhead is the duration of freshwater rearing and the type of habitat that is used. It is the freshwater rearing period that is most vulnerable to land-use practices, including forest practices. Consequently, those species of fish with the longer stream-rearing periods are more likely to be adversely affected by forest practices.

Spring chinook salmon, coho salmon, and steelhead juveniles typically spend 1 or 2 years rearing in streams prior to migrating to the sea. Similarly, sockeye salmon usually spend a year rearing in a lake prior to their migration. In contrast, fall chinook and chum salmon migrate to the ocean as fry (small sub-yearling fish). Chum salmon usually complete their migration shortly after emergence (Wydoski and Whitney 1979), while fall chinook may have a prolonged migration period that occurs throughout the summer (Dawley et al. 1986). Five of the species (kokanee, rainbow, cutthroat, bull, and Dolly Varden trout) have life history forms that do not have a marine phase. They live their entire lives in freshwater.

During the period of freshwater rearing, Pacific salmon and trout have life-stage and species-specific habitat requirements for spawning and rearing. Important aspects to spawning habitat include substrate size (size of pebbles, rocks, and composition of the bottom of the stream or water body), water depth, and water velocity (Bjornn and Reiser



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1991). In general, the larger species utilize larger substrates and deeper and faster water. Tail-outs to pools (the downstream end where the pool changes to a riffle) that meet criteria for these features are generally considered optimal spawning areas because stream structure maximizes the passage of oxygenated water through redds (nests dug by the fish in the substrate). However, runs and riffles are also used during spawning.

Following emergence from the redd, salmon and trout fry typically use shallow and slow-moving areas of a stream. Optimal depths and velocities increase as the fish grow, but preferred areas are usually associated with some form of cover, usually pools with large woody debris or boulders. Differences among the species are apparent in the degree of flexibility for utilizing riffles, runs, and other habitat features. Drifting insect larvae and benthic macroinvertebrates account for the majority of food items eaten by juvenile salmon and trout within streams.

In contrast to other salmon species, sockeye fry migrate to a lake shortly after emergence where shallow nearshore areas are preferred habitat. As sockeye fry grow, they begin to move offshore and have a characteristic diurnal vertical migration timed for utilization of zooplankton food sources.

4.10.3.2 Aquatic Ecosystem (Habitat Components)

Key physical components of the aquatic ecosystem include channel morphology or structure (floodplains, streambanks, channels), water quality, and water quantity. Habitat complexity is created and maintained by rocks, sediment, large woody debris, and favorable water quantity and quality. Upland and riparian areas influence aquatic ecosystems by supplying sediment, woody debris, and water. Disturbances such as landslides and floods are important mechanisms for delivery of wood, rocks, and pebbles that contribute to the streambed.

Natural channels are complex and contain a mixture of habitats differing in depth, velocity, and cover (Bisson et al. 1987). They are formed during storm events that have associated water flows that mobilize sediment in the channel bed (Murphy 1995). The hydrology, or the way water moves through the watershed, combined with its geology, hillslope characteristics, and riparian vegetation determine the nature of stream channel morphology (Sullivan et al. 1987, Beschta et al. 1995). Therefore, activities in these areas would be expected to affect the shape and form of the stream channel. For example, substantial increases in volume and frequency of peak flows can cause streambed scour and bank erosion. A large sediment supply may cause aggradation (i.e., filling and raising the streambed level by sediment deposition) and widening of the stream channel, pool filling, and a reduction in gravel quality (Madej 1982). Upslope activities (e.g., timber harvest, land clearing, and road development) can change channel morphology by altering the amount of sediment or water contributed to the streams. This, in turn, can disrupt the balance of sediment input and removal in a stream (Sullivan et al. 1987).

Streams that lack a balance between pools and riffles are often less productive for salmon and trout than streams that have more complex structure. Pools are used as holding and



resting areas for adult fish prior to spawning, deep water cover for protection, and cool water refugia during low-flow summer months. Riffles are important for re-oxygenation of water, habitat for food organisms such as aquatic macroinvertebrates, and as rearing areas for fish (Gregory and Bisson 1997). Intensive timber harvest next to the water body has been reported to decrease pool depth, surface area, and the general diversity of pool character (Ralph et al. 1994). Possible mechanisms include decreased occurrence of large woody debris (which can help to form and stabilize pools) and filling of remaining pools with bed material.

The following describes components to the aquatic ecosystem that are influenced by forest practices. These include coarse sediment, fine sediment, hydrology, large woody debris, leaf/needle litter recruitment, floodplains and off-channel features, water temperature, forest chemicals (contaminants), and fish passage.

Coarse Sediment. A certain amount of bedload material is necessary to provide substrate for cover and spawning habitat for fish. Increased levels of coarse sediment bedload above background levels can, however, lead to stream bank instability, pool filling, and changes in the water transport capacity of the channel (Spence et al. 1996). Higher flows are required to mobilize larger sediment sizes. Consequently, the recovery period for streams with severe coarse sediment aggradation could range from decades to 100 years or more. The major factors influencing the excessive delivery of sediment to a stream include the intensity and location of stream bank erosion, mass-wasting events, and road and culvert failures.

Fine Sediment. Fine sediment can degrade the quality of fish habitat by increasing water turbidity that restricts sunlight penetration. Sediment can also fill the pores between the gravel and prevent the flow of oxygen-rich water to fish eggs that may be deposited there (Bjornn and Reiser 1991). Fine sediments and larger particles such as sand-sized fractions can also smother fish eggs and developing young in the gravel, clog pores or breathing surfaces of aquatic insects, physically smother them, or decrease available habitat (Spence et al. 1996, Washington Forest Practices Board 2001).

Biological effects of increased turbidity may include a decrease in primary productivity of algae and periphyton due to the decrease in light penetration. Declines in primary productivity can adversely affect the productivity of higher trophic levels such as macroinvertebrates and fish (Gregory et al. 1987). Turbidity can also interfere with feeding behavior or cause gill damage in fish (Hicks et al. 1991), but may provide some benefits. For example, it can provide cover from predators (Gregory and Levings 1998).

Important factors related to forest management activities that can influence the excessive delivery of fine sediment to a stream include the presence of wetlands (see Section 4.9) and adequate streamside vegetation to filter fine sediment from hillslopes and road surface erosion (see Section 4.6).

Hydrology. The amount of water provided to aquatic ecosystems at critical times is important for sustaining fish and other aquatic species. Many fish have become adapted to



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natural flow cycles for feeding, spawning, migration, and survival needs. The timing, magnitude, and duration of peak and low flows must be sufficient to create and maintain riparian and aquatic habitat. Wetland areas are also an important component to hydrology by storing water and later releasing it directly to streams or through groundwater. In general, low- or base-level stream flows that occur during the late summer often limit habitat for rearing juvenile salmon and trout. High winter flows and floods that scour the streambed can be detrimental to eggs or young fish that may be incubating in the stream gravels. Rain-on-snow events are a common reason for flooding and streambed scour on the west of the Cascade Mountains and can be influenced by management activities such as timber harvest and roads (see Section 4.7).

Large Woody Debris. Large woody debris includes trees and tree pieces greater than 4 inches in diameter and 6 feet long (Keller and Swanson 1979, Bilby and Ward 1989). While large woody debris is considered one of the most important components of high-quality fish habitat (Marcus et al. 1990), the value of a particular piece of large woody debris in providing aquatic habitat depends on the stream size, tree species, and numerous other factors (see Section 4.3). Large woody debris provides food and building materials for many aquatic life forms and is important for stream nutrient cycling, macroinvertebrate productivity, and cover for juvenile and adult fish (Marcus et al. 1990). Large woody debris is also the primary channel-forming element in some channel types and affects many aspects of channel structure including stream roughness, sediment storage, water retention, energy dissipation, and fish habitat (Lisle 1986, Swanson et al. 1987, Marcus et al. 1990, Martin and Robinson 1998). Pools formed by stable accumulations of large woody debris provide important habitat for rearing salmon and trout, particularly in winter (Heifetz et al. 1986, Murphy et al. 1986).

Field studies in streams flowing through old Douglas-fir forests in coastal Oregon and Washington have shown that the number of woody debris pieces varies by channel width and size of debris under undisturbed conditions (Bilby and Ward 1989, Washington Forest Practices Board 1995). Coniferous wood (e.g., Douglas-fir or cedar) is more resistant to decay than deciduous wood (e.g., alder). Therefore, coniferous wood has a greater longevity in a stream (Cummins et al. 1994 in Spence et al. 1996).

In general, information on large woody debris must be viewed from the perspective of past timber harvest activity in an area, historical floods that have removed or redistributed large woody debris, and the activities that were performed to actively remove large woody debris (Maser and Sedell 1994). Long-term potential large woody debris recruitment from existing mature or old forest riparian zones would be anticipated to be higher than younger or recently clearcut areas (see Section 4.3.3.1, Riparian Functions).

Leaf and Needle Recruitment. The abundance and diversity of macroinvertebrate food sources to salmonids is dependent upon the primary algae and detrital food sources. Forest harvest activities affect the food chain by changing the relative macroinvertebrate production between herbivores and detritivores (Gregory et al. 1987). Many bacterial and macroinvertebrate species rely directly on detrital material from (disintegration of) leaf and



needle litter, branches, and stems from the surrounding riparian zone vegetation. Some estimates indicate that leaf and needle recruitment may provide up to 60 percent of the total energy input to stream communities (Richardson 1992). In streams containing spawning habitat for Pacific salmon, significant influxes of nutrients from the marine environment occur during the decomposition of fish carcasses (Bilby et al. 1996).

Other macroinvertebrate species rely on aquatic algae that primarily use dissolved chemical nutrients, require solar radiation, and are affected by the amount of shade present in a stream reach. Although shade is important for maintaining cool water temperatures, more shade or complete shading does not always maximize aquatic productivity. The availability of instream algae can be a limiting factor in some streams. Algae and other sources of vegetable matter are at the lowest level of the food chain and important to higher trophic level production such as fish. High levels of shade can result in low levels of algae production even if adequate nutrient sources are present (Gregory et al. 1987). Under unmanaged conditions, forested lands generally have low light and low primary productivity in **low-order streams** with high canopy cover. In contrast, primary productivity in wide, **high order streams** is generally unaffected by riparian management because adequate light penetration occurs even under mature riparian conditions (Gregory et al. 1987).

Floodplains and Off-channel Habitat. Floodplains and off-channel areas are important components of aquatic habitat that provide side channels, wall-base channels, backwater alcoves, ponds, and wetlands. They also provide important habitat seasonally to particular life stages of fish as well as input of organic matter and large woody debris. Floodplains and off-channel habitat are protected under the Habitat Conservation Plan by establishing Riparian Management Zones that begin at the outer edge of the 100-year floodplain.

Water Quality (Temperature and Dissolved Oxygen). Water temperature plays an integral role in the biological productivity of streams and is an important factor influencing dissolved oxygen levels. Water temperature and dissolved oxygen levels can affect all aspects of salmon and trout life in fresh water including:

- incubation and egg survival in stream gravel;
- emergence, feeding, and growth of fry and juvenile fish;
- outmigration of young fish;
- adult migration, holding and resting; and
- pre-spawning and spawning activities.

In coldwater species such as salmon and trout, water temperatures in the range of 70°F (about 21°C) or greater can cause death within hours or days (Oregon Department of Environmental Quality 1995). In general, water temperatures of 53° to 58°F (11.8° to 14.6°C) have been found to provide a properly functioning condition for juvenile salmon and trout. However, bull trout require much lower temperatures during spawning (39° to



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50°F [4 to 10°C]) and egg incubation (34° to 43°F [1 to 6°C]) (Oregon Department of Environmental Quality 1995).

Increases in water temperature in forest streams can often be traced to a reduction in shade-producing riparian vegetation along fish-bearing and tributary streams that supply water to other fish-bearing streams (see Riparian Areas, Section 4.3). Long-term sublethal temperature effects can be detrimental to the overall health of a population, as can short-term acute effects of warm water temperatures on coldwater aquatic species. Heat stress may accumulate such that increased exposure for juvenile fish in an environment in which growth is reduced or the inability to meet increased metabolic (energy) demands increases their susceptibility to disease (Oregon Department of Environmental Quality 1995).

Forest Chemicals. Water quality contaminants (e.g., petroleum products, chemicals, fertilizers, herbicides, sewage, and heavy metals) can severely impair aquatic ecosystems either by sublethal (e.g., reduced growth) or lethal effects (e.g., fish kills). The water quality contaminants considered herein are pesticides and herbicides used to prevent tree diseases and deter pest plant species that compete with trees for nutrients, space, and light.

Fish Passage. Upstream migration of adult salmon, steelhead, and trout to spawning areas or redistribution of rearing fish to potential habitat in upstream areas can be impeded or blocked by a number of different mechanisms. These mechanisms can include water temperature, dissolved oxygen, turbidity, and natural and man-made physical barriers (Reiser and Bjornn 1979).

Stream crossings by forest roads are the most common passage barrier influenced by forest practices. Barriers such as culverts used at stream crossings can prevent passage due to high water velocities, restricted depths, excessive elevation of the culvert (too high above stream level) for successful entry, size and length, and other factors. Shallow water depths from conditions such as low flow can also impede or prevent passage by causing riffles between pools to become completely dry or lack sufficient depth for passage. Similarly, debris jams can prevent or delay upstream passage (Reiser and Bjornn 1979).

4.10.4 Environmental Effects

The changes proposed to policies and procedures under the Alternatives are described in Chapter 2. Other policies and procedures that affect fish and riparian conditions are described in Appendix C. Policy or procedural changes would directly or indirectly affect fish or fish habitat by modifying the intensity and frequency of harvest activities in areas (primarily riparian areas) that are available to harvest. Potential changes include those related to trust ownership groups, harvest flow, value- versus volume-based control of timber harvest, minimum forest stand regeneration age, and northern spotted owl conservation management strategies.



4.10.4.1 Alternatives Analysis by Habitat Component

Coarse Sediment. Excessive coarse sediment entering streams is commonly the result of forest management activities on unstable slopes or failures at road-stream crossings. All of the Alternatives would avoid activities on unstable slopes and are expected to have similar amounts of new road construction using modern construction standards. Consequently, no significant difference is expected among the Alternatives relative to coarse sediment entering streams. Please see Geomorphology, Soils, and Sediment (Section 4.6) for additional details.

Fine Sediment. Other than restoration activities, none of the Alternatives proposes activities within the 25-foot no-harvest buffer along Types 1 through 4 streams, except for yarding corridors, roads, and restoration activities. Consequently, none of the Alternatives is likely to have a significant adverse effect on stream bank stability or sediment filtering capacity from surface erosion as long as appropriate mitigation measures are also implemented, such as Road Maintenance and Abandonment Plans. Please see Geomorphology, Soils, and Sediment (Section 4.6) and Riparian Areas (Section 4.3) for additional details.

Hydrology. The effects of the Alternatives on hydrology (the way that water moves through the landscape) were analyzed based upon the potential changes in the amount of hydrologically mature forest in the rain-on-snow zone, and amount of harvest in the riparian areas. Constraints to harvest in the rain-on-snow zone are the same under all Alternatives. Consequently, none of the Alternatives allows harvest of hydrologically mature forest in rain-on-snow zones below critical levels (66 percent of the zone). Harvest levels in the riparian zone under Alternatives 5 and 6 may have minor short-term adverse effects to the local peak flows of the waterbody, particularly if ground-based yarding systems are used in riparian zones, but these minor effects are unlikely to be detectable at the watershed scale.

Large Woody Debris. The potential of adding more large woody debris is expected to improve under all of the Alternatives. Over the short term, Alternatives 1, 2, 3, and 4 are expected to produce about the same amount of riparian area included in stand development stages with very large trees, i.e., trees more than 30 inches in diameter (about 19 percent of the riparian land class). Alternative 6 is predicted to result in slightly less large woody debris than Alternatives 1 through 4 (with about 17 percent of the riparian land class with very large trees), while Alternative 5 is predicted to result in substantially less large woody debris (about 9 percent with very large trees). Very large trees are important for supplying larger streams with functional large woody debris (Section 4.3).

Over the long term, Alternative 1 is expected to result in the highest amount of riparian area (about 56 percent of the riparian land class) in stand development stages with very large trees, followed in descending order by Alternative 4 (52 percent), Alternative 2 (49 percent), Alternative 3 (46 percent), Alternative 5 (45 percent), and Alternative 6 (41 percent). Although Alternative 6 is predicted to have the lowest area of very large trees among the Alternatives, it is predicted to result in the highest amount (11 percent) of



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riparian land class area in fully functioning or old natural forest stand development stages, while Alternative 3 is predicted to have the lowest amount (about 7 percent).

The major feature that distinguishes these two stand development stages from other stages with very large trees is the presence of higher levels of decadence such as snags, down coarse woody debris, and epiphytes. Alternative 1, which is expected to have the highest area with very large trees, is predicted to have about 9 percent of riparian land class area in fully functioning or old natural forest stand development stages. Consequently, over the long term, Alternatives 5 and 6 appear to produce higher riparian function on more of the riparian land class relative to Alternative 1, but with the trade-off of having substantially less area supporting very large trees in the riparian land class during the Habitat Conservation Plan period.

Based upon the model outputs, the potential for adverse effects to fish resources from Alternatives 1 through 4 for the first decade is expected to be minimal in all planning units because harvest activity levels are relatively low at less than 7 percent of the riparian land class and average about 8 percent for all decades and planning units. The differences would generally be minor except for lands managed under Alternative 6, and the Olympic Experimental State Forest Planning Unit under Alternative 5. Under Alternative 6, large woody debris recruitment potential could be lower in certain planning units during some decades, because of the relatively high level of activity to as much as about 73 percent of the riparian land class during a decade, primarily from low volume thinning. Under Alternative 5, riparian timber harvest in the Olympic Experimental State Forest is expected to result in disturbance levels as high as approximately 33 percent in an individual decade. Alternatives 5 and 6 would likely produce more acres of fully functioning riparian stands and stands on a trajectory towards full function because of thinning and other active silvicultural management. However, these Alternatives would also likely result in fewer riparian acres of very large trees within the Habitat Conservation Plan planning period. Those areas with very large trees that do not receive treatments, particularly under Alternatives 1 and 4, may require substantially longer periods (over 100 years; Carey et al. 1996) to achieve full riparian function.

Additional details concerning large woody debris recruitment and the likely effects of the Alternatives can be found in Riparian Areas (Section 4.3).

Floodplains and Off-channel Habitat. Protection of floodplains and off-channel habitat is not expected to differ among the proposed Alternatives. Harvest activities prior to implementation of the Habitat Conservation Plan sometimes resulted in the harvest of trees right to the stream edge and did not consider protection to floodplains and off-channel habitat. Consequently, these areas are expected to improve under all Alternatives, while riparian vegetation in these areas grows. Active management under Alternatives 2, 3, 5, and 6 could result in thinning or hardwood conversion activities in these areas that may result in short-term adverse effects, but are expected to be beneficial over the long term.



Water Quality. Water temperatures in westside trust lands would likely be maintained or improved over the long term under all Alternatives. The presence of very large trees is important for maintaining stream shade and cool water temperatures. Over the short term, Alternatives 1 through 4 are expected to result in about the same amount of area in stand development stages with very large trees, while Alternative 6 is predicted to have slightly less area, and Alternative 5 is predicted to have substantially less area. Over the long term, Alternative 1 is expected to have the highest amount of riparian area in stand development stages with very large trees followed in descending order by Alternatives 4, 2, 3, 5, and 6.

Relative to Alternative 1, improvements in stream shade anticipated under Alternatives 2 through 6 may be less because of the harvest of riparian trees and potentially greater numbers of yarding corridors. However, such activities would generally be relatively minor in scope except under Alternative 6 and in the Olympic Experimental State Forest under Alternative 5. Alternative 6 could result in lower levels of stream shading in some planning units during some decades, because of the relatively high level of disturbance to as much as approximately 73 percent of the riparian land class during a given decade. Under Alternative 5, the Olympic Experimental State Forest would be expected to experience disturbance levels as high as about 33 percent in a decade.

Additional details concerning water quality and the likely effects of the Alternatives can be found in Water Quality (Section 4.8) and Riparian Areas (Section 4.3).

Forest Chemicals. Use of forest chemicals such as fertilizers and herbicides under Alternatives 1 through 4 is expected to be little or none. Alternatives 5 and 6 propose higher use in terms of frequency and amounts. However, mitigation measures implemented by DNR, such as manual application in riparian zones, exist to reduce the likelihood of forest chemicals entering streams. Consequently, none of the Alternatives is expected to result in significant adverse affects to water quality and the associated fish resource from forest chemicals. Please see Water Quality (Section 4.8) for additional details.

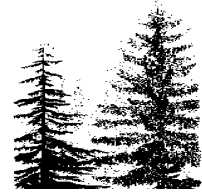
Leaf and Needle Recruitment. Relative to current conditions, leaf and needle litter recruitment to streams would be expected to increase in the long term under all of the Alternatives due to growth of trees in the riparian zone. However, relative to Alternative 1, the improvement in leaf and needle litter production may be limited because of the harvest of some riparian trees and potentially greater numbers of yarding corridors. The amounts of these activities are expected to be generally minor, except for under Alternative 6 and in the Olympic Experimental State Forest under Alternative 5.

Fish Passage. The amount of new road construction needed for stand access is expected to be similar under all Alternatives. New roads and any stream crossings needed would be built using current standards that require adequate fish passage. Replacement of sub-standard stream crossings that are considered passage problems will occur as part of DNR's road maintenance and abandonment program. Fish passage at man-made structures would be expected to improve over time under all of the Alternatives.



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4.11 PUBLIC UTILITIES AND SERVICES

4.11.1 Summary of Effects

This section analyzes the potential effects of the Alternatives on public utilities and services. This analysis considers the potential effects of the Alternatives on harvest volumes because harvest volumes potentially affect trust revenues, which are used by some beneficiaries to fund public utilities and services. A separate financial analysis prepared by the DNR addresses the potential impacts to trust revenues in financial terms. This section also considers the potential effects of the proposed Alternatives on transportation infrastructure. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

The Alternatives present a wide array of direct economic benefits to the beneficiaries. Potential effects on transportation infrastructure would vary by Alternative, with larger projected harvest volumes resulting in increased logging truck traffic. None of the Alternatives are expected to result in any probable significant adverse environmental impacts. Potential impacts would occur in the setting of the total forest management activity within the state of Washington and surrounding regions; current DNR harvests represent about 13 percent of total western Washington harvest. Logging companies harvesting timber from forested state trust lands must meet Washington State Department of Transportation weight requirements and DNR regularly meets with local government officials and engineers to discuss the effects of logging-related traffic (DNR 1992b). These measures would help mitigate potential impacts associated with increased road traffic.

4.11.2 Introduction

This section provides an overview of the potential effects of the proposed Alternatives on public utilities and services. Public utilities and services were not directly raised as issues during scoping, but some issues were raised with respect to revenue generation from management of westside forested trust lands. These include concerns with predictable and reliable flows of revenue to trust beneficiaries.

The potential effects of the Alternatives on harvest volumes, and therefore trusts revenues, are considered here in general terms because these revenues are mainly used by beneficiaries to fund public utilities and services, particularly schools. The potential effects of the proposed Alternatives on transportation infrastructure are also discussed in this section.

4.11.3 Affected Environment

4.11.3.1 Forested State Trust Lands and Trust Beneficiaries

There are three types of forested state trust land: Federal Grant, Forest Board, and Community College Forest Reserve.



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Federal Grant Lands

The Omnibus Enabling Act of 1889 set aside 2 square miles out of every 36 (2 Sections in each Township) in the state to provide financial support for the common schools. The Act also granted additional Sections of land to other state institutions. These lands, known as “Federal Grant Lands,” consist of eight specific trusts, including:

- **Agricultural school** lands, which support Washington State University in Pullman.
- **Capitol building** lands, which support the construction of state office buildings on the capitol campus in Olympia.
- **Charitable, educational, penal, and reformatory institutions** lands, which support these public institutions.
- **Common school** lands, which support the construction of public schools.
- **Normal school** lands, originally designated to support the state teachers colleges, which have become the regional universities: Western Washington University, Central Washington University, Eastern Washington University, and The Evergreen State College.
- **Scientific school** lands, which support Washington State University.
- **University original** lands, which support the University of Washington. Only a small amount of that acreage remains.
- **University transfer** lands, which were originally part of the charitable, educational, penal, and reformatory institutions trust but were designated by the state legislature to provide additional support to the University of Washington.

Approximately 844,000 of the 2.2 million acres of Federal Grant Trust lands in the state of Washington were located in westside counties in 2001 (Table 4.11-1). Approximately 92 percent (773,000 acres) of the Federal Grant trust lands in westside counties were forested (Table 4.11-1). These acreages are shown by trust in Table 4.11-1. The Common School lands accounted for about 508,000, or 66 percent, of forested Federal Grant Trust acres in western Washington.

Annual statewide timber harvest is presented by trust beneficiary for Fiscal Year 1998 to Fiscal Year 2002 in Table 4.11-2. Total harvest ranged from 494.8 million board feet in Fiscal Year 2001 to 578.3 million board feet in Fiscal Year 2000, with an annual average of 543.7 million board feet. Federal Grant Trust land accounted for 52 percent of the average annual total; Forest Board lands accounted for the remaining 48 percent.

Federal Grant Trust lands generated a statewide annual average income of \$141.2 million between Fiscal Year 1998 and Fiscal Year 2002, with the Common School Grant lands accounting for 73 percent or \$103.1 million of this total (Table 4.11-3). Total annual income generated by Federal Grant Trust lands has fluctuated over the last 5 years, ranging from \$100.2 million in Fiscal Year 2002 to \$164.8 million in Fiscal Year 1999 (Table 4.11-3).

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Table 4.11-1. Forested State Trust Lands Managed by DNR, by Trust Beneficiary

	Total Acres ^{1/}	Total Forested Acres ^{1/}	Westside Acres ^{2/3/}	Westside Forested Acres ^{3/4/}
Federal Grant Trust Lands				
Agricultural School Grant (Washington State University)	70,733	56,783	27,579	26,210
Capitol Building Grant	108,281	100,290	91,715	85,460
Charitable, Educational, Penal and Reformatory Institutions Grant	70,278	40,141	29,289	26,810
Common School, Indemnity, and Escheat Grants	1,746,020	1,103,452	560,377	508,307
Normal School Grant (Eastern Washington University, Central Washington University, Western Washington University, and The Evergreen State College)	64,304	57,005	34,757	32,549
Scientific School Grant (Washington State University)	80,455	68,549	56,268	52,995
University Grants (University of Washington) Original and Transferred	86,806	56,954	43,723	41,130
Federal Grant Trust Land Total	2,226,877	1,483,174	843,708	773,461
Forest Board Lands				
Purchase and Transfer	625,178	595,241	603,025	563,604
Community College Forest Reserve^{5/}				
Community College Forest Reserve Lands	3,339	3,339	na	na
Total for all Trust Lands	2,852,055	2,078,415	1,446,733	1,337,065

Data Sources:

^{1/} DNR 2001 (various tables)

^{2/} DNR Geographic Information System data 2003

^{3/} DNR Geographic Information System data identifies 79,672 acres in 9 other categories: Administrative Site, Tidelands - 2nd Class, Land Bank, CEP&RI Transferred, Under Contract to Private Party, Natural Area Preserve, Natural Resources Conservation Area, Non-specific Non-fiduciary Trust, and Water Pollution Control Division Trust Land.

^{4/} These data compiled from the OPTIONS model identify 50,558 acres in the 9 other categories identified in footnote 3.

^{5/} Although addressed in the DNR Forest Resource Plan, the Community College Forest Reserve is not part of a trust.



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Table 4.11-2. Annual Statewide Timber Harvest by Trust Beneficiary, Fiscal Year 1998 to Fiscal Year 2002 (in million board feet)

	Fiscal Year					5-year Average
	1998	1999	2000	2001	2002	
Federal Grant Trust Lands						
Agricultural School Grant (Washington State University)	12.4	13.6	7.9	5.3	8.4	9.5
Capitol Building Grant	26.4	26.6	34.3	28.3	24.2	28.0
Charitable, Educational, Penal and Reformatory Institutions Grant	14.1	12.3	12.4	11.5	22.1	14.5
Common School, Indemnity, and Escheat Grants	202.4	212.3	228.4	178.8	157.3	195.8
Normal School Grant (Eastern Washington University, Central Washington University, Western Washington University, and The Evergreen State College)	13.4	6.9	12.1	10.5	8.2	10.2
Scientific School Grant (Washington State University)	23.7	30.0	19.1	19.5	14.1	21.3
University Grants (University of Washington) Original and Transferred	8.5	6.1	0.9	6.9	0.2	4.5
Federal Grant Land Trust Total	300.8	307.8	315.1	260.8	234.6	283.8
Forest Board Lands (state forestlands)						
Purchase and Transfer	252.0	267.8	263.2	253.4	259.6	259.2
Community and Technical College Reserve						
College Reserve	1.8	0.3	0.0	0.8	0.6	0.7
Total for all Beneficiaries	554.7	576.0	578.3	515.0	494.8	543.7

Notes:

1. Reported trust harvest in 1999 and 2000 included harvest credited to Forest Board Repayment, Parkland Reserve Trust, and Water Pollution Control, which resulted in total harvest volumes of 610.9 and 628 million board feet for 1999 and 2000, respectively.

2. Timber is sold before it is harvested. Timber sale contracts average 2 years in length, with timber harvest schedules determined by individual purchasers. Revenues are generated when timber is harvested.

3. DNR's Fiscal Year extends from July 1 through June 30. Fiscal Year 2002, for example, extended from July 1, 2001, through June 30, 2002.

Data Sources: DNR 1998, 1999, 2000, 2001, 2002a

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Table 4.11-3. Annual Statewide Income Generated by Trust Beneficiary, Fiscal Year 1998 to Fiscal Year 2002 (\$ million)^{1/}

	Fiscal Year ^{2/}					5-year Average
	1998	1999	2000	2001	2002	
Federal Grant Trust Lands						
Agricultural School Grant (Washington State University)	5.8	5.8	3.2	1.7	1.8	3.7
Capitol Building Grant	9.4	10.6	11.8	8.4	10.5	10.1
Charitable, Educational, Penal and Reformatory Institutions Grant	8.2	6.5	7.5	4.5	6.3	6.6
Common School, Indemnity, and Escheat Grants	105.7	119.4	119.5	103.4	67.6	103.1
Normal School Grant (Eastern Washington University, Central Washington University, Western Washington University, and The Evergreen State College)	5.1	5.2	7.9	5.8	5.5	5.9
Scientific School Grant (Washington State University)	11.2	11.4	7.7	6.5	6.8	8.7
University Grants (University of Washington) Original and Transferred	4.0	5.9	1.3	2.4	1.8	3.1
Federal Grant Trust Lands Total	149.3	164.8	158.9	132.8	100.2	141.2
Forest Board Lands						
Purchase and Transfer	121.6	144.9	113.6	89.2	79.6	109.8
Total for all Beneficiaries	270.9	309.7	272.5	222.0	179.8	251.0

Data Sources: DNR 1998, 1999, 2000, 2001, 2002a

^{1/} Annual income figures are adjusted for inflation and presented in 2002 dollars.

^{2/} DNR's Fiscal Year extends from July 1 through June 30. Fiscal Year 2002, for example, extended from July 1, 2001 through June 30, 2002.

On average, timber sale revenue accounted for 84.2 percent of annual Federal Grant Trust land income between Fiscal Years 1998 and 2002. This percentage ranged from 76.7 percent in Fiscal Year 2001 to 91.3 percent in Fiscal Year 1998. Timber sale revenue as a share of annual Federal Grant Trust lands income declined between Fiscal Years 1998 and 2001, but increased from 76.7 percent in Fiscal Year 2001 to 83.0 percent in Fiscal Year 2002 (Table 4.11-4). The decline between Fiscal Years 1998 and 2001 was particularly notable for the Common School Grant, which saw timber sale revenue decrease from 82.3 percent of total trust revenue in 1998 to just 53.5 percent in Fiscal Year 2001 (Table 4.11-4). About half of the decline is the result of the purchase of timber by the legislature for transfer out of trust ownership into parks and other non-consumptive uses through the trust land transfer program, which is limited to the Common School, Indemnity and Escheat Grants lands.



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Table 4.11-4. Timber Sale Revenue as a Proportion of Annual Income by Trust Beneficiary, Fiscal Year 1997 to Fiscal Year 2002 (Percent)

	Fiscal Year					5-year Average
	1998	1999	2000	2001	2002	
Federal Grant Trust Lands						
Agricultural School Grant (Washington State University)	95.8	94.8	93.5	83.4	86.5	90.8
Capitol Building Grant	96.0	97.5	98.1	98.2	96.1	97.2
Charitable, Educational, Penal and Reformatory Institutions Grant	80.3	78.3	81.8	71.4	82.1	78.8
Common School, Indemnity, and Escheat Grants	82.3	68.8	64.6	53.5	62.4	66.3
Normal School Grant (Eastern Washington University, Central Washington University, Western Washington University, and The Evergreen State College)	95.3	96.4	98.5	98.0	96.6	96.9
Scientific School Grant (Washington State University)	93.4	95.0	94.0	86.2	82.2	90.2
University Grants (University of Washington) Original and Transferred	90.7	93.8	80.3	88.8	81.8	87.1
Federal Grant Land Trust Total	85.1	75.5	71.7	61.5	71.2	73.0
Forest Board Lands						
Purchase and Transfer	98.9	99.4	99.5	99.4	98.0	99.0
Total for all Trust Lands	91.3	86.7	83.3	76.7	83.0	84.2

Data Sources: DNR 1998, 1999, 2000, 2001, 2002a

Note: DNR's Fiscal Year extends from July 1 through June 30. Fiscal Year 2002, for example, extended from July 1, 2001, through June 30, 2002.

Forest Board Lands

There are two types of Forest Board lands (state forestlands): Transfer and Purchase. Acquisition of Forest Board Transfer lands was authorized by statute in 1927 to manage logged and abandoned properties formerly owned by individuals and corporations. These lands reverted to the counties when the original owners failed to pay property taxes and were subsequently transferred to the state in the 1920s and 1930s. Revenues produced from Forest Board Transfer lands support county services and junior taxing districts (such as schools, roads, and cemetery districts) in which they are located, although these lands are managed as one trust.

Forest Board Purchase lands were acquired by the state by purchase in 1923 and later by gift or purchase. Revenues go to the county and junior taxing districts in which they are

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located and the state general fund for the benefit of public schools. These lands are not in trust status, but are managed to earn revenue.

There were approximately 625,000 acres of Forest Board lands in the state of Washington in 2001, with the majority (603,000 acres) located in westside counties (Table 4.11-1). Forest Board lands (purchase and transfer) generated a statewide annual average income of \$109.8 million between Fiscal Year 1998 and Fiscal Year 2002, about 44 percent of the total income generated by DNR for trust beneficiaries (Table 4.11-3). Total annual income generated by Forest Board lands has fluctuated over the last 5 years, ranging from \$79.6 million in 2002 to \$144.9 million in 1999 (Table 4.11-3). On average, timber sale revenue accounted for 99.0 percent of statewide annual Forest Board lands income between Fiscal Years 1998 and 2002 and stayed relatively constant over this period (Table 4.11-4).

DNR state timber sale revenue generated from Forest Board lands (purchase and transfer) is presented as an approximate proportion of total county revenue for the 17 westside counties in Table 4.11-5. This estimated contribution ranges from approximately 0.1 percent of total county revenue in King County to 16.1 percent in Clallam County (Table 4.11-5).

Table 4.11-5. DNR State Timber Sale Revenue as a Proportion of Total County Revenue, 2001

County	Trust Income (\$) ^{1/}	Total County Revenue (\$) ^{2/}	Trust Income as a % of Total Revenue
Clallam	5,908,678	36,611,186	16.1
Clark	2,289,382	247,081,550	0.9
Cowlitz	2,095,225	65,207,943	3.2
Grays Harbor	2,021,929	57,488,226	3.5
Jefferson	1,598,013	22,826,429	7.0
King	1,427,462	2,178,468,989	0.1
Kitsap	1,062,454	164,251,480	0.6
Lewis	5,096,739	56,336,813	9.0
Mason	1,977,874	38,383,105	5.2
Pacific	2,344,181	18,351,891	12.8
Pierce	981,549	388,521,292	0.3
Skagit	6,227,049	77,808,865	8.0
Skamania	1,208,272	16,234,088	7.4
Snohomish	13,238,245	525,842,849	2.5
Thurston	7,845,488	126,481,521	6.2
Wahkiakum	915,544	8,214,047	11.1
Whatcom	6,753,540	83,340,599	8.1

Data Sources:

^{1/} DNR 2001

^{2/} Washington State Auditor 2003



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Community College Forest Reserve

In addition to Federal Grant and Forest Board lands, DNR also manages a small amount (3,339 acres) of forest lands for community colleges. Although these lands are addressed in the 1992 Forest Plan, they are not part of a trust.

4.11.3.2 Transportation Infrastructure

The Final Environmental Impact Statement for the DNR Forest Resource Plan indicated that DNR operated about 12,000 miles of roads, building approximately 60 miles of new road each year. About 7,500 miles of these roads are used for transportation, with another 3,600 miles maintained only for fire prevention and management. DNR closes and decommissions roads that are no longer needed.

Timber harvest, fire control, and recreation activities all generate traffic on DNR forest roads. The largest single source of traffic is associated with DNR's management of forested state trust lands, although recreation access may be the largest use in some areas. Traffic from these activities extends from the network of DNR and private forest roads onto county roads, as well as state and interstate highways. County and state roads are affected to varying degrees by logging trucks and other traffic generated from timber harvesting on DNR-managed lands, as well as timber harvesting on other types of land ownership.

Timber harvest data are presented by westside county for state lands (including DNR managed lands) in Table 4.11-6. This table also presents state harvest as a percentage of total harvest (state, federal, and private) by county. Data are presented for 2001, with the annual average for 1997 to 2001 also provided. Harvest volumes from all lands in 2001 were lower than the 1997 to 2001 average for all but two westside counties. Harvest volumes from state lands in 2001 were the same or higher than the 1997 to 2001 average in 6 of the 19 westside counties (Table 4.11-6).

Assuming an average load per logging truck of 4.5 thousand board feet suggests that harvest from all lands in Grays Harbor County in 2001, for example, generated about 98,500 logging truck trips. Using the same assumption, harvest from state lands in Snohomish County in the same year generated about 11,000 logging truck trips. It should be noted that each logging truck trip consists of two legs: one way with a full load, and one way empty.

4.11.4 Environmental Effects

4.11.4.1 State Trust Land and Trust Beneficiaries

This section summarizes projected harvest levels by Alternative. It compares these with annual average harvest levels over the past 5 years to offer some insight into the potential effects of the proposed Alternatives on trust revenues. This analysis allows for comparison among Alternatives, and provides some indication of their relative value. It does not, however, attempt to project future revenues. Actual revenues will be determined by a number of factors, including prices for timber that are determined in the wider

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Table 4.11-6. State and All Ownerships Timber Harvest by County, 1997 to 2001 (in million board feet)

County	2001			1997-2001 Average		
	State Harvest ^{1/}	Total Harvest ^{2/}	State as a % of Total	State Harvest ^{1/}	Total Harvest ^{2/}	State as a % of Total
Clallam	34.9	230.9	15.1	40.0	259.4	18.4
Clark	15.7	53.9	29.0	23.7	81.5	15.5
Cowlitz	38.6	248.1	15.5	32.5	265.5	9.8
Grays Harbor	25.5	443.3	5.8	42.2	520.4	6.8
Island	0.0	10.7	0.0	0.2	15.0	3.3
Jefferson	11.4	61.8	18.5	13.6	70.4	35.5
King	11.0	144.2	7.6	12.7	155.9	6.2
Kitsap	2.9	25.8	11.4	4.4	32.7	9.9
Lewis	37.5	441.1	8.5	57.8	433.7	11.0
Mason	12.6	144.4	8.7	19.0	177.3	7.9
Pacific	27.6	277.4	9.9	40.8	303.3	10.8
Pierce	17.8	200.1	8.9	13.8	216.9	4.3
San Juan	0.0	1.7	0.0	0.0	2.7	3.1
Skagit	23.3	121.8	19.1	41.2	150.5	22.5
Skamania	8.3	31.4	26.4	13.8	46.9	17.1
Snohomish	50.2	122.4	41.0	44.3	134.8	20.7
Thurston	49.0	107.4	45.6	51.5	119.8	27.3
Wahkiakum	19.2	96.5	19.9	16.9	89.9	16.5
Whatcom	37.6	78.9	47.7	29.5	89.0	24.6
Total Westside Counties	423.0	2,841.8	14.9	498.0	3,165.5	13.1

Data Source: DNR (various years)

^{1/} The state harvest volumes presented in this table are for harvest from all state lands, not just those managed by DNR.

^{2/} The total timber harvest volumes presented in this table include timber harvest from all land ownerships, including Native American, Forest Industry, private, state (included DNR-managed lands), National Forest, and other.

marketplace. These issues are discussed in the separate financial and economic analysis prepared for this project. While projected annual average harvest allows a comparison among Alternatives, it does not take into account variations in harvest costs among Alternatives. Potential purchasers factor expected harvest costs into the amount they bid for a particular timber sale, with higher cost sales receiving lower bids. As a result, it should be noted that while projected harvest levels allow some comparison among Alternatives, increases in harvest do not necessarily represent a commensurate increase in revenue.

Projected 2004 to 2013 annual average harvests are presented, by trust beneficiary and Alternative, in Table 4.11-7. The largest projected total harvest would occur under



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Alternatives 5 and 6, with total harvests of about 819 and 781 million board feet, respectively. Lower levels of harvest would occur under Alternatives 2 and 3, approximately 537 and 663 million board feet, respectively, with the lowest total harvest levels projected for Alternatives 1 and 4, approximately 396 and 411 million board feet, respectively. These projections suggest that higher trust revenues would be generated under Alternatives 5 and 6 than Alternatives 1 and 4. In addition, it may be noted that, under Alternatives 3, 5, and 6, the total projected average annual harvest for 2004 to 2013 would be higher than the 1998 to 2002 annual average.

The largest amount of harvest would occur on Forest Board lands and Common School, Indemnity, and Escheat Grant lands under all Alternatives. Forest Board lands range from 45 percent of the total projected volume under Alternative 5, to 55 percent under Alternative 3. The Common School, Indemnity, and Escheat Grant lands range from 27 percent of the projected total under Alternative 3, to 33 percent under Alternatives 2, 5, and 6.

Projected annual average harvest for 2004 to 2013 for Forest Board lands would be higher than the 1998 to 2002 annual average under Alternatives 3, 5, and 6, while projected average annual harvest for the Common School, Indemnity, and Escheat Grant lands would be higher under Alternatives 5 and 6 only.

4.11.4.2 Transportation Infrastructure

The following analysis considers projected average annual harvest by Alternative and county as a general indication of the relative potential impact of the proposed Alternatives on transportation infrastructure. Assuming an average load of 4.5 thousand board feet per logging truck, Alternatives with larger projected harvest volumes would result in more logging traffic with larger associated potential effects to transportation infrastructure. The following discussion of projected average annual harvest by county allows a relative comparison to be made by Alternative and county, but does not attempt to quantify these potential effects in terms of projected infrastructure improvement costs. Although the modeling results do not produce precise harvest schedules, the results can represent a likely distribution of harvest levels over time at the county level. More precise short-term harvest schedules will be developed through operational level planning.

Projected annual average harvest is presented, by county, for 2004 to 2013 in Table 4.11-8. Alternative 6 would result in the largest total average annual volume harvested, followed by Alternatives 5, 3, 2, 4, and 1 in that order. Total projected average annual harvest for 2004 to 2013 would be higher than the 1998 to 2001 annual average under Alternatives 2, 3, 5, and 6. Based on an estimated 4.5 thousand board feet/logging truck, the number of logging trips generated by the proposed Alternatives would range from approximately 88,000 under Alternative 1 to 182,000 under Alternative 5, compared to a 1997 to 2001 annual average of approximately 110,700 (Table 4.11-9).

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Table 4.11-7. Projected Annual Average Harvest by Trust Beneficiary and by Alternative, 2004 to 2013 (in million board feet)

Trust Beneficiary	5-Year Annual Average ^{1/}	Alternative					
		1	2	3	4	5	6
Federal Grant Trust Lands							
Agricultural School Grant (Washington State University)	9.5	9.4	8.9	7.4	12.3	12.5	12.6
Capitol Building Grant	28.0	33.7	37.3	46.0	28.9	74.2	58.8
Charitable, Educational, Penal and Reformatory Institutions Grant	14.5	14.7	15.3	17.2	11.7	19.7	25.9
Common School, Indemnity, and Escheat Grants	195.8	115.9	176.1	181.2	122.5	269.2	261.3
Normal School Grant (Eastern Washington University, Central Washington University, Western Washington University, and The Evergreen State College)	10.2	6.4	11.6	10.8	7.2	14.4	14.2
Scientific School Grant (Washington State University)	21.3	23.1	22.3	28.7	24.6	33.1	32.0
University Grants (University of Washington) Original and Transferred	4.5	2.3	13.1	10.0	4.8	22.9	9.8
Federal Grant Land Trust Total	283.8	205.5	284.7	301.2	212.0	446.0	414.5
Forest Board Lands							
Purchase and Transfer	259.2	189.1	251.1	361.3	197.9	372.1	365.7
Community and Technical College Reserve							
College Reserve	0.7	1.5	1.0	0.4	1.3	0.9	0.7
Total	543.7	396.1	536.8	662.8	411.2	819.0	781.0

^{1/} This is the annual average for DNR-managed lands for 1998 to 2002 (see Table 4.11-2).

Data Source: Model output data – timber flow levels

The geographic distribution of the projected harvest and associated logging truck traffic over this period would vary by Alternative. Under Alternatives 5 and 6, annual average projected harvest would be largest in Clallam and Jefferson Counties, with Alternatives 5 and 6 generating about 28,700 and 14,100 logging trips in Clallam County, respectively. Under Alternatives 1 and 4, annual average projected harvest would be largest in Skagit and Snohomish Counties, with Alternatives 1 and 4 generating about 10,100 and 11,200 logging trips in Skagit County, respectively. Projected harvest under Alternative 2 would be largest in Jefferson and Skagit Counties, with an estimated annual average 11,900 and 11,200 logging trips, respectively. Projected harvest under Alternative 3 would be largest in Mason and Lewis Counties, with an estimated annual average 13,800 and 13,500 logging trips, respectively.

State and county roads are affected to varying degrees by logging trucks and other traffic associated with timber harvest activities. The Washington State Department of



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Transportation and the appropriate counties maintain state and county roads with monies from gasoline taxes, as well as property taxes in the case of county roads. Existing roads on DNR-managed state lands are improved as part of DNR's road development program as traffic conditions warrant. Similarly, public roads are improved when required by increased traffic (DNR 1992b).

Logging companies who harvest timber from forested state trust lands must meet Washington State Department of Transportation weight requirements. DNR regularly meets with local government officials and engineers to discuss the effects of logging-related traffic (DNR 1992b). These measures would help mitigate potential impacts associated with increased road traffic.

Table 4.11-8. Projected Annual Average Harvest by County, by Alternative, 2004 to 2013 (in million board feet)

County	5-year Annual Average ^{1/}	Alternative					
		1	2	3	4	5	6
Clallam	40.0	22.7	37.4	57.6	24.9	129.1	63.6
Clark	23.7	29.6	37.9	56.3	22.9	45.8	53.3
Cowlitz	32.5	32.3	29.2	46.1	28.3	39.9	51.1
Grays Harbor	42.2	23.1	41.3	49.4	31.1	47.8	70.7
Jefferson	13.6	9.4	53.6	54.9	10.0	98.1	50.4
King	12.7	15.6	12.9	15.3	9.5	27.7	21.6
Kitsap	4.4	6.4	5.6	10.4	4.3	7.5	10.3
Lewis	57.8	38.3	46.1	60.7	32.8	57.3	80.1
Mason	19.0	31.0	28.0	62.1	23.7	38.9	61.7
Pacific	40.8	13.2	19.3	23.9	36.1	46.8	60.4
Pierce	13.8	13.3	13.3	8.3	4.1	17.3	5.3
San Juan	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Skagit	41.2	45.5	50.3	37.0	50.2	63.4	62.1
Skamania	13.8	10.6	30.9	43.9	6.7	45.8	13.3
Snohomish	44.3	44.4	49.1	29.8	46.1	54.3	56.7
Thurston	51.5	28.0	37.4	55.2	29.0	32.7	49.6
Wahkiakum	16.9	7.4	7.9	19.0	23.6	24.5	24.7
Whatcom	29.5	25.2	36.5	33.0	27.8	42.0	46.0
Total	497.7	396.1	536.8	662.8	411.2	819.0	781.0

^{1/} This is the annual average for 1997 to 2001 (see Table 4.11-6). Note that this differs from the period used in Table 4.11-7 because total state harvest data are not yet readily available for 2002. It should also be noted that these data are for the calendar year rather than DNR's fiscal year.

Data Source: Model output data – timber flow levels

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Table 4.11-9. Projected Annual Average Logging Truck Traffic by County, by Alternative, 2004 to 2013 (number of trips^{1/})

County	5-year Annual Average ^{2/}	Alternative					
		1	2	3	4	5	6
Clallam	8,900	5,000	8,300	12,800	5,500	28,700	14,100
Clark	5,300	6,600	8,400	12,500	5,100	10,200	11,800
Cowlitz	7,200	7,200	6,500	10,200	6,300	8,900	11,400
Grays Harbor	9,400	5,100	9,200	11,000	6,900	10,600	15,700
Jefferson	3,000	2,100	11,900	12,200	2,200	21,800	11,200
King	2,800	3,500	2,900	3,400	2,100	6,200	4,800
Kitsap	1,000	1,400	1,200	2,300	1,000	1,700	2,300
Lewis	12,800	8,500	10,200	13,500	7,300	12,700	17,800
Mason	4,200	6,900	6,200	13,800	5,300	8,600	13,700
Pacific	9,100	2,900	4,300	5,300	8,000	10,400	13,400
Pierce	3,100	3,000	3,000	1,800	900	3,800	1,200
San Juan	0	0	0	0	0	0	0
Skagit	9,200	10,100	11,200	8,200	11,200	14,100	13,800
Skamania	3,100	2,400	6,900	9,800	1,500	10,200	3,000
Snohomish	9,800	9,900	10,900	6,600	10,200	12,100	12,600
Thurston	11,400	6,200	8,300	12,300	6,400	7,300	11,000
Wahkiakum	3,800	1,600	1,800	4,200	5,200	5,400	5,500
Whatcom	6,600	5,600	8,100	7,300	6,200	9,300	10,200
Total	110,700	88,000	119,300	147,200	91,300	182,000	173,500

^{1/} Logging truck traffic is an estimate of logging trips based on an average truck load of 4.5 thousand board feet per truck.

^{2/} This is the annual average for 1997 to 2001 (see Table 4.11-6). Note that this differs from the period used in Table 4.11-7 because total state harvest data are not yet readily available for 2002. It should also be noted that these data are for the calendar year rather than DNR's fiscal year.

Data Source: Model output data – timber flow levels



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4.12 CULTURAL RESOURCES

4.12.1 Summary of Effects

This section analyzes the environmental effects on cultural resources. The analysis examines the effects of prospective changes to current policy, and uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

While there are relative differences among the Alternatives, adverse effects on cultural resources are expected to be insignificant under all Alternatives. Forest Resource Plan Policy No. 24 requires protection of such resources and DNR is committed to consulting with Native American tribes and other interested parties about areas of cultural importance to them. These two forms of mitigation are anticipated to minimize risk to cultural resources.

4.12.2 Introduction

Cultural resources are districts, sites, buildings, structures, and objects that contain evidence of past human activities or that play an active part in the traditional cultures of the disparate ethnic groups that comprise Washington's populace. Legislative bodies at the federal and state levels have recognized cultural resources as important for the education and inspiration of future generations of Americans, whatever their backgrounds.

4.12.3 Affected Environment

4.12.3.1 Archaeological Overview of Western Washington

Despite nearly a century of scientific research in the region, the archaeology of western Washington is not well understood. This is particularly true of the foothill and lower mountain settings where most of DNR-managed forest lands can be found. What is known about the prehistoric archaeology of the region is biased toward the lowlands, particularly coastlines, where most development occurs and, therefore, where most archaeological surveys have been conducted. Not all DNR-managed lands have been intensively surveyed for archaeological resources. The same is true for nearby lands of the National Forests. Most sites in these forests have been found along streams or on high ridges, but this may be due in part to a tendency for land managers to survey what they consider high probability areas more intensively than lower probability slopes.

For a background summary of cultural resources in western Washington, see Appendix D, Section D.6.

4.12.4 Environmental Effects

Timber harvesting can have a severe negative impact on cultural resource sites. Culturally modified trees, if not recognized before harvest, can be cut down and destroyed. Historic equipment may be damaged or moved from its original location, changing its context and association. Archaeological sites, both historic and prehistoric, are likely to be severely



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damaged by the movement of logging equipment, dragging of logs, and piling of slash into burn piles. Although lithic scatters will not be entirely destroyed and may retain some scientific or cultural value, the relative positions of artifacts and most if not all cultural features, such as hearths, rock alignments, food processing facilities, and remains of dwellings are likely to be disturbed beyond recognition.

Although pre-harvest archaeological surveys will identify many sites that can be protected by avoidance, surveys do not find 100 percent of all sites, and avoidance can sometimes be incomplete, so impacts can still occur.

Cultural uses of forestlands by Indian tribes can be affected by timber harvests. On the negative side, elimination of old timber stands, or exposing important spirit questing or sacred sites to view by cutting surrounding trees reduces people's ability to use such sites and may eliminate them altogether as components of the living culture. Logging in lowlands eliminates cedar trees, which are the source of basket making and ceremonial materials; culturally important plants that grow in mature forest stands may become less abundant. On the positive side, timber harvesting, like the traditional burning of forests, encourages the growth of berry-producing species and provides forage for game animals. Cedar is also promoted on many DNR-managed lands by the removal of competing tree species.

4.12.4.1 DNR Cultural Resource Protection Procedures

To avoid adverse impacts on cultural resources, DNR follows procedures derived from Section 106 of the National Historic Preservation Act (U.S.C. 470 et seq.). First, during the field layout or compliance stage or a timber sale, staff identify known sites and areas with high site potential by using DNR's Total Resource Application Cross-Reference System and soliciting input from Native American groups and others with specialized cultural resource knowledge.

Second, lands identified as having a high probability for containing potential cultural resources are subjected to archaeological survey at 25-foot intervals. Cultural resource finds are confirmed, documented with the State Office of Archaeology and Historic Preservation, and, as appropriate, the affected Native American tribe is notified. DNR frequently enters into memoranda of agreement with tribal governments to protect traditional cultural properties and maintain tribal access to resources and localities important to the continued practice of their traditional cultures.

These procedures greatly reduce the probability that timber harvest activities will negatively affect cultural resources. They do not, however, entirely eliminate those effects for two reasons. First, only potential cultural resources and high probability areas are surveyed, leaving sites that might occur in lower probability areas unprotected. Second, archaeological surveys, particularly in forested environments, sometimes are not able to locate existing cultural resources, which lay hidden under vegetation and/or soil. Despite conscientious efforts by DNR staff, some cultural resource sites may be missed by surveys and sites may be damaged by timber harvest practices. However, DNR protection practices



reduce the potential of impacts to cultural resources to the point that impacts from all Alternatives are expected to be minor.

4.12.4.2 Approach to Analysis

Although impacts to cultural resources would be minor under all Alternatives, potential effects to resources vary by Alternative. The level of effort needed to protect these resources also varies and to a greater degree than do the anticipated effects.

It is not possible to assess the actual impact each sustainable harvest Alternative would have on cultural resources or the level of effort that would be needed to protect these resources. This is because only a fraction of DNR-managed forest lands have been surveyed for cultural resources to date. It is also because this is a programmatic analysis, which does not identify specific land parcels for harvest. This analysis is, therefore, qualitative and addresses differing probabilities for encountering and affecting cultural resources based on the frequency of cut and the extent to which stream corridors are affected.

4.12.4.3 Analysis Criteria

The archaeological site records maintained at the Washington Office of Archaeology and Historic Preservation were reviewed to obtain a general impression of the types of prehistoric archaeological sites found in each of the planning units and their environmental settings. That analysis demonstrated that between 90 and 95 percent of documented sites in each area were located within about 400 yards of a stream, river, lake, or body of saltwater (i.e., partially within areas designated in the Habitat Conservation Plan as Wetland Management Zone and Riparian Management Zone).

Sites found near streams include culturally modified cedars, village sites, shell middens, open camps, lithic scatters, rock shelters, cemeteries, and petroglyphs. Rock shelters, quarry sites, huckleberry processing sites, and a few lithic scatters occurred at greater distances from water. Many earlier logging sites, particularly including skid roads and large stumps with springboard cuts are also most likely to be preserved in these settings. Consequently, Alternatives that propose more harvest activity in streamside environments would require a greater level of effort to protect potential cultural resources, and would have a greater probability to affect cultural resources that may be missed by archaeological surveys. They are, therefore, ranked higher in impact and level of effort.

Stands greater than 150 years old are more likely to still contain culturally modified trees, never-disturbed archaeological sites, and huckleberry processing features. Older stands are also more likely to be used by Indian tribes for traditional cultural practices and may need to be addressed in memoranda of agreement with the affected tribes. Alternatives that propose more harvest in old forest stands are, therefore, ranked as having a greater potential to affect cultural resources and to require greater effort to protect these resources.



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Harvest frequency is used as a criterion because the more frequently an area is logged, the more damage may occur to archaeological sites that may remain undiscovered following archaeological surveys. Alternatives with higher harvest frequencies are, therefore, ranked as having a higher potential to affect cultural resources.

4.12.4.4 Results of the Analysis, by Alternative

Table 4.12-1 presents the results of analysis of the six sustainable harvest Alternatives according to their potential impact on cultural resources. This may also be read as the relative level of effort that would be required under each Alternative to protect cultural resources using archaeological surveys, site documentation, and consultation and memorandums of agreement developed with Native American tribes.

Table 4.12-1. Ranking of Alternatives According to their Effect on Cultural Resources
(A Rank of 1 Equals Lowest Potential for Impacts)

Alternative	Streamside Effects	Harvest of Older Stands ^{1/}	Harvest Frequency	Rank
1	Harvest in Riparian Management Zone and Wetland Management Zone prohibited (1)	No additional stipulations (4)	60 yr (5)	2
2	Maintain canopy closure (relative density of 45 or greater) over 90% of riparian management area (3)	No additional stipulations (4)	60 yr (5)	5
3	Same as 2 (3)	No additional stipulations (4)	60 yr (5)	5
4	Harvest in Riparian Management Zone and Wetland Management Zone prohibited (1)	Harvest of >150 year stands deferred (1)	80 yr (1)	1
5	Maintain canopy closure (relative density of 45 or greater) over 70% of riparian management area (3)	10 to 15% to be maintained in old forest conditions (2)	40 yr (6)	4
6	Maintain canopy closure (relative density of 35 or greater) over 70% of riparian management area (4)	10 to 15% to be maintained in old forest conditions (2)	Variable 40-80 yr (2)	3

Data Source: Evaluations of Alternatives, Section 2.6

1/ Old forest research areas are deferred and 20 percent of Olympic Experimental State Forest lands are maintained in old forest conditions in all Alternatives.

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In Table 4.12.1, columns describing streamside effects, harvest of old forest stands, and harvest frequency provide rationale for the ranking. Impact ranking under each criterion is given in parentheses. Overall ranks are an ordering of the total ranks of all three criteria. In making this calculation, the weight of streamside effects is considered to be double that of the other two criteria. The Alternative with the highest rank (Alternative 4) is expected to have the least potential impact on cultural resources and require the lowest level of effort to protect such resources.

Alternatives 2 and 3, which have only moderate protection of streamside lands and no additional protection of old forests, are expected to have the greatest potential impact on cultural resources and require the greatest level of effort to protect these resources.

Alternative 4, which protects old forests and streamside environments and would have the longest harvest interval, is likely to have the least potential impact. Also, less effort would be needed for cultural resource protection.



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4.13 RECREATION

4.13.1 Summary of Effects

This section analyzes the potential effects of the Alternatives on recreation. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

Environmental impacts on recreation resources are assessed in relation to harvest level. More intensive harvest would have a larger impact on the landscape, potentially affecting the quality of recreation experiences in adjacent and nearby areas. None of the Alternatives is expected to result in any probable significant adverse environmental impacts. Potential effects on recreation may be mitigated on a case-by-case basis during operational planning prior to the initiation of harvest activities. Potential effects may be mitigated by employing harvest systems that minimize potential visual effects and by relocating or rerouting affected recreation facilities, particularly trails, as appropriate. All of the Alternatives would meet the minimum requirements of DNR policies and procedures that address recreation and public access (Forest Resource Plan Policies Nos. 25 and 29 [DNR 1992b]).

The effects of the proposed Alternatives on fish and wildlife could, in turn, affect recreational fishing and hunting on DNR westside trust lands. Fishing and hunting opportunities on DNR-managed westside trust lands could be positively affected to the extent that increased amounts and quality of habitat contribute to greater abundance of fish and game populations in some or all of the planning units. The potential effects on fish and wildlife are discussed in more detail in Sections 4.10 and 4.4, respectively.

4.13.2 Affected Environment

Approximately 40 percent of all uplands in the state of Washington are publicly owned, with the federal government managing 12.9 million acres or 28 percent of the state (Interagency Committee for Outdoor Recreation 2002). Statewide, DNR manages about 2.9 million acres of trust lands, with about 1.4 million forested acres located in westside counties. These state trust lands are managed for the support of trust beneficiaries with recreation being a secondary use allowed under the Multiple Use Act (Chapter 79.68 RCW, recodified at Laws of 2003, Ch. 334, sec. 555(2)). The Multiple Use Act allows for recreational use as long as the uses do not damage resources and the use is compatible with trust management responsibilities (Forest Resource Plan Policy No. 29 [DNR 1992b]).

DNR generally provides public access for multiple uses on state forested trust lands. There are, however, situations where DNR controls vehicular or other access. Public access may be closed, restricted, or limited to protect public safety; to prevent theft, vandalism, and garbage dumping; to protect soils, water quality, plants, and animals; or meet other Forest



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Resource Plan or Habitat Conservation Plan objectives (Forest Resource Plan Policy No. 25 [DNR 1992b]).

A recent assessment of outdoor recreation in the state of Washington found that residents participated in at least 170 different types of outdoor recreation in 15 major categories (Interagency Committee for Outdoor Recreation 2002). Population growth of about 20 percent over the last decade has resulted in increased numbers of people engaged in recreation, even though the percent of the population actively participating in outdoor recreation declined over this period. More than half of the state's population currently participates in some form of outdoor recreation. Roughly half of outdoor recreation activity in the state is local, with the other half shared between state, federal, and private providers.

Outdoor recreation activities that occur on state lands include walking/hiking, horseback riding, off-road vehicle use, picnicking, camping, hunting, fishing, and more. The Interagency Committee for Outdoor Recreation assessment found that 53 percent of the state's population participated in the walking/hiking recreation category, with 20 percent picnicking, 13 percent camping, 13 percent fishing, 9 percent using off-road vehicles, and 6 percent hunting/shooting (Interagency Committee for Outdoor Recreation 2002).

Participation in all of these activities, with the exception of fishing and hunting/shooting, is projected to increase over the next 20 years. Increases over the next 10 years are expected to range from 5 to 10 percent for camping to 20 percent for picnicking. The numbers of people fishing and hunting/shooting are projected to decrease by 5 percent and 15 percent, respectively, over the same period (Interagency Committee for Outdoor Recreation 2003).

Westside trust lands that receive significant public use include Capitol Forest in Thurston County, Tahuya State Forest in Mason County, Yacolt Burn State Forest in Skamania County, and Tiger Mountain State Forest in King County. Recreation facilities in these locations include campgrounds, picnic areas, hiking trails, off-road vehicle trails, and interpretive facilities (Interagency Committee for Outdoor Recreation 2003, pages 45-46).

The existing DNR road system receives heavy recreation-related use, providing the public with access to specific recreation areas, such as trailheads, campgrounds, and picnic areas. In addition, a large portion of recreational users of trust lands use the road system as the primary focus of their recreational activity—driving the road systems and occasionally dispersing across the landscape to hunt, birdwatch, gather mushrooms or berries, or engage in some other non-facility oriented activity. A recent survey, for example, estimated that approximately 50 percent of back road and “off of road” fuel use in the state of Washington was for uses other than off-road motorized activities (off-road vehicles and snowmobiling) and non-motorized activities (hiking, mountain biking, cross-county skiing, and equestrian). The other back road and off of road uses that made up about 50 percent of total fuel use included hunting, driving, sightseeing, camping, and fishing (Hebert Research, Inc. 2003).

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Statewide, DNR manages about 1,150 miles of recreation trails. Approximately 840 miles or 73 percent of these trails are located on westside forested trust lands, with 347 miles (41 percent of westside total) designated as multiple-use motorized trails. The remaining miles are designated multiple-use, non-motorized (34 percent), hiker only (13 percent), and winter (12 percent) (Table 4.13-1).

Table 4.13-1. DNR Westside Recreation Trails, By Region (in Miles)

	Central	Northwest Olympic	Southwest	South Puget Sound	Total
Multiple-Use Motorized	87	30	15	17	199
Multiple-Use Non-Motorized	80	43	0	60	102
Hiker Only	6	41	4	1	57
Winter	0	0	0	0	100
Total	173	114	19	78	457

Source: Personal communication, Lisa Anderson, 2003

Roughly 457 miles of the westside trails (54 percent) are located in the South Puget Sound area, which includes Mason, Pierce, King, and Kitsap Counties and the Tahuya, Green Mountain, Tiger Mountain, and Tahoma State Forests.

DNR also manages some westside lands as Natural Area Preserves and Natural Resource Conservation Areas to protect examples of undisturbed ecosystems, rare plant and animal species, and unique geologic features. These areas, which are off-base for harvest, help support trust management objectives by managing and conserving habitat for Habitat Conservation Plan species, where appropriate.

Natural Area Preserves are generally available only for educational and scientific access. Natural Resource Conservation Areas are available for low impact recreation, such as nature study, walking, and day hiking, as well as for research and education. Mt. Si Natural Resource Conservation Area in King County, for example, is an important hiking destination (Interagency Committee for Outdoor Recreation 2002).

4.13.3 Environmental Effects

Management objectives under the proposed Alternatives could affect recreation use of westside trust lands in three main ways. First, harvest activities could have primarily negative effects on existing recreation activities in and around harvested areas. This is reflected in the public concerns raised during scoping for this project (Appendix A). Concerns were expressed about the integration of forest management and recreation, and the location of harvest units relative to recreation areas.



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The linear nature of the trail system suggests that trail use would be the most likely recreation activity to be affected by increased harvest activities. Trails in active harvest areas are likely to be closed, moved, or decommissioned as a result of harvest activities. In addition, trails, campgrounds, picnic areas, and some overlook areas could be negatively affected by noise, dust, and traffic generated during logging activities. Higher harvest volumes would likely increase these potential effects.

Second, higher harvest volumes would also result in more logging truck traffic on DNR roads used by the public for recreation purposes, which could potentially affect a large portion of recreation visitors, depending on the Alternative selected. Estimates of logging truck traffic that would be generated are presented by Alternative in Table 4.11-9 and discussed in Section 4.11.3.2, which discusses potential impacts to transportation infrastructure. Total projected annual average truck traffic generated over the next decade (2004 to 2013) ranges from approximately 90,000 truck trips under Alternative 1, about 85 percent of the annual average for 1997 to 2001, to roughly 174,000 truck trips under Alternative 6, about 1.67 times the 1997 to 2001 annual average. Third, the impacts of the proposed Alternatives on fish and wildlife could in turn affect recreational fishing and hunting on westside trust lands.

As noted above, potential effects on recreation are likely to increase with harvest intensity. This is not necessarily a linear relationship. An increase in the amount of harvest would not necessarily result in a commensurate increase in impacts. In other words, doubling the amount of harvest, for example, would not necessarily result in double the impact. More intensive harvest may, however, result in more complex issues. In addition, potential impacts would vary by user group, with more intensive harvest potentially benefiting some recreation user groups, such as road users, while negatively affecting other groups, such as trail users. The potential impacts of more intensive harvest on road users are also likely to vary by location, with some groups potentially benefiting from new road construction, while other groups would be negatively affected by increased levels of logging truck traffic on existing roads.

The assessment presented in this environmental analysis is programmatic, meaning that it establishes direction and potential harvest levels for broad land areas rather than scheduling activities on specific patches of land. As a result, it is not possible to identify specific tracts of land or recreational facilities that would be affected by the Alternatives. In addition, the model results for the six Alternatives do not provide a precise schedule of where and when harvest would occur under the different Alternatives. Rather, the results for each Alternative represent one of a number of potential paths to achieve the long-term objectives of that Alternative and are used in this analysis for comparison among Alternatives rather than an accurate prediction of the future.

Given these constraints, the following analysis addresses the effects of the Alternatives in terms of the projected amount of land that would be subject to high-volume removal harvest (defined as harvests removing more than 20 thousand board feet per acre in volume) and the projected amount of open forest under each Alternative. This analysis proceeds from the assumption that more intensive harvest would have larger potential



effects during harvest in terms of noise, air, and traffic impacts, as well as the resulting post-harvest impact to the landscape.

Projected harvest under the proposed Alternatives is grouped into three harvest types for the purposes of this analysis. These harvest types, referred to as low volume, medium volume, and high volume removal harvest, represent groupings of silvicultural treatments that produce similar ranges of harvest intensity. Low-volume removal harvest (defined as harvests removing less than 11 thousand board feet per acre in volume) includes silvicultural treatments like small wood thinning. Medium-volume removal harvest (defined as harvests removing between 11 and 20 thousand board feet per acre in volume) includes silvicultural treatments such as variable density thinning, hardwood management, and uneven-aged management. High-volume removal harvest (more than 20 thousand board feet per acre volume harvests) includes regeneration harvests with legacy retention, heavier partial harvest, and some variable density thinnings.

The percent of harvest type (low, medium, or high removal volume) acres by decade is presented by Alternative in Section 4.2, Forest Structure and Vegetation (Figure 4.2-2). Average annual acres of high-volume removal harvest are presented by Alternative and decade in Figure 4.13-1. These data indicate that high-volume removal harvest would occur over larger areas under Alternatives 5 and 6 for all decades that make up the 64-year planning period with two exceptions. These exceptions occur in 2044 through 2053 when high-volume removal harvest would occur over a larger area under Alternative 3 than Alternative 5, and 2064 through 2067 when high-volume removal harvest would occur over a larger area under Alternative 3 than Alternative 6. High-volume removal harvest would occur over smaller areas under Alternatives 1 and 4 for all of the decades under consideration (Figure 4.13-1).

These projected levels of harvest provide one general indicator of potential recreation impacts, with Alternatives 5 and 6 likely to have relatively high impacts compared to Alternatives 1 and 4. These trends tend to hold true across four of the six planning units, with some limited exceptions when high-volume removal harvest would occur over larger areas under Alternative 3 than Alternatives 5 and/or 6. This occurs more frequently in the South Puget unit with high-volume removal harvest occurring over larger areas under Alternative 3 than Alternatives 5 and 6 in four of the seven time periods analyzed (2004 to 2013, 2034 to 2043, 2044 to 2053, and 2064 to 2067).

The projected area of high-volume removal harvest is noticeably different for the Olympic Experimental State Forest than it is for the other five units, with the area harvested under Alternative 6 lower than the projected harvest areas under Alternatives 2, 3, and 5 across all time periods. This is reflected in the high volume removal harvest acres shown by Alternative in Figure 4.13-2. Viewed in terms of total acres harvested, high volume removal harvest is generally lower in the South Puget and Straits Planning Units than in the other four units (Figure 4.13-2).



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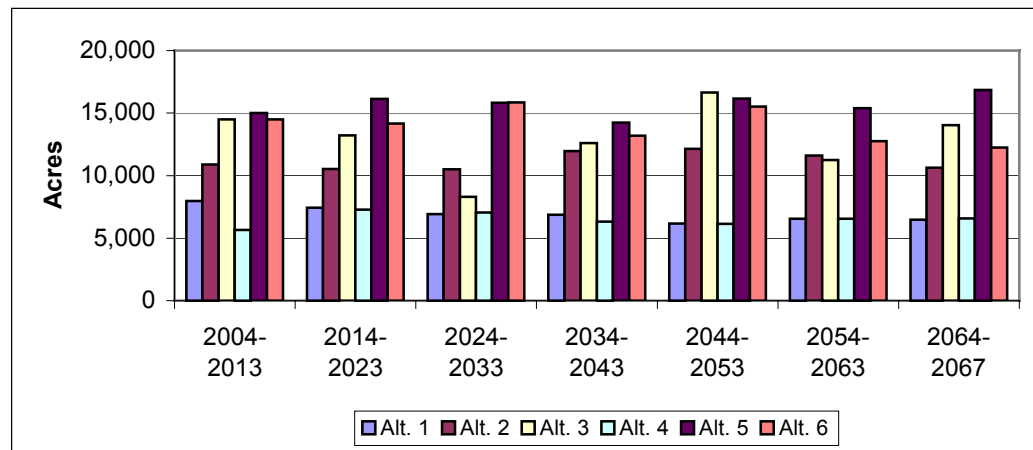


Figure 4.13-1. Average Annual High Volume Removal Harvest Acres, by Alternative and Decade

Notes:

1. High volume removal harvest would likely result in greater than 20 thousand board feet per acre volume harvests.
2. Average annual harvest acres are calculated by dividing total harvest acres per decade by 10 for the six full decades. Average annual acres for 2064 through 2067 were calculated by dividing total acres by 4.

Source: OPTIONS model output data

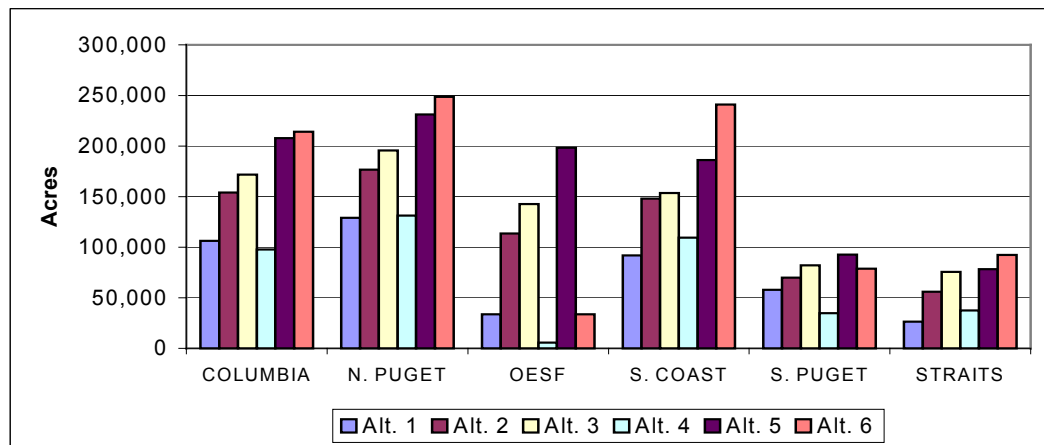


Figure 4.13-2. Total High Volume Removal Harvest Acres by Alternative and Planning Unit

Data Source: Model output data – timber flow levels

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In addition to having larger potential effects during harvest in terms of noise, air, and traffic impacts, more intensive harvest would have a larger impact on the landscape potentially affecting the quality of recreation experiences in adjacent and nearby areas. The amount of high-volume removal harvest viewed in acres by decade (discussed above) provides one perspective on these potential effects. A second perspective is provided by considering the projected amount of open forest. Figure 4.4-1 in Section 4.4 (Wildlife) identifies the percent of total forest area in three different forest structure classes (ecosystem initiation forest, competitive exclusion forest, and structurally complex forest) under each Alternative. Alternatives with greater levels of ecosystem initiation forest would result in greater amounts of open forest.

In the short term (2013), there is no meaningful difference among the Alternatives. In the long term (2067), the amount of ecosystem initiation forest would be largest under Alternative 5, followed by Alternatives 3 and 6, with Alternatives 1, 4, and 2 having the smallest amounts. Alternatives 3, 5, and 6 generally result in greater increases in open forest across all six planning units, with the exception of the South Puget Planning Unit where Alternative 6 produces smaller increases than most Alternatives in both time periods, and Alternative 1 has higher increases than most. Model results indicate Alternative 6 would produce the smallest increases of open forest in the Olympic Experimental State Forest.

The effects of the proposed Alternatives on fish and wildlife could, in turn, affect recreational fishing and hunting on DNR westside trust lands. Fishing and hunting opportunities on DNR westside trust lands could be positively affected to the extent that increased amounts and quality of habitat contribute to greater abundance of fish and game in some or all of the planning units. All six Alternatives would likely result in increases in suitable habitat for deer and elk in almost all time periods. The largest short-term increases (by 2013) are projected to occur under Alternatives 4 and 5, with the largest increases occurring over the long term under Alternatives 2, 3, and 5. The potential effects on fish and wildlife are discussed in more detail in Sections 4.10 and 4.4, respectively.

Potential effects on recreation may be mitigated on a case-by-case basis during operational planning prior to the initiation of harvest activities. Potential effects may be mitigated by employing harvest systems that minimize potential visual effects and by relocating or rerouting affected recreation facilities, particularly trails, as appropriate. All of the Alternatives would meet the minimum requirements of DNR policies and procedures that address recreation and public access (Policies No. 25 and 29).



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4.14 SCENIC RESOURCES

4.14.1 Summary of Effects

This section analyzes the potential effects of the Alternatives on scenic resources. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential environmental impacts. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

None of the Alternatives is expected to result in any probable significant adverse environmental impacts on scenic resources. Lands managed for timber production under all Alternatives would be managed under DNR's visual management procedure (14-004-080), which seeks to minimize potential impacts to scenic resources by managing harvest activities with respect to sensitive viewshed areas. Potential visual effects associated with the proposed Alternatives may be mitigated on a case-by-case basis during operational planning prior to the initiation of harvest activities. Operational planning by DNR includes policies and procedures related to green-up (growing young trees for a specific time before adjacent trees may be cut), reforestation, and harvest unit size that contribute to the management of forested landscapes.

4.14.2 Introduction

This section addresses the potential effects of the proposed Alternatives on scenic resources. Scenic value concerns raised during public scoping for this project included requests that DNR consider impacts to scenic resources, including size and shape of clearcuts and their location relative to highways.

4.14.3 Affected Environment

DNR manages approximately 1.5 million acres of westside trust lands. Approximately 1.4 million acres of these lands are forested. These lands span vegetation zones from near sea level to mountaintops and include a wide range of landscape types and scenic resources characteristic of western Washington, including coastal and high elevation forests, alpine lakes, and rocky shorelines. High quality scenery, especially scenery with natural-appearing landscapes, is generally regarded as an important resource that enhances peoples' quality of life and influences the quality of recreation experiences and, in some cases, adjacent property values.

Although DNR primarily manages trust lands to produce income for the various trusts and maintain a healthy ecosystem, visual concerns are also considered. Visual concerns do not, however, apply to all areas. Areas where potential visual concerns exist include major highway corridors, cities and towns, adjacent housing developments, and trails and other recreation areas. DNR's visual management procedure (PR 14-004-080) outlines the guidelines whereby DNR regions locate areas that may be managed to reduce the visual impact of harvest and road-building activities. In cases where visual concerns do apply, management decisions seek a balanced solution among visual impact, income, and ecosystem objectives.



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In addition to westside forested trust lands that are managed for the support of trust beneficiaries, DNR also manages some westside lands as Natural Area Preserves (26,400 acres) and Natural Resource Conservation Areas (80,500 acres). These lands are managed to preserve the best remaining examples of many ecological communities and to protect outstanding native ecosystems; habitat for endangered, threatened, and sensitive plants and animals; and scenic landscapes, respectively. These lands, which are off-base for harvest, help support management objectives by managing and conserving habitat for wildlife, where appropriate.

4.14.4 Environmental Effects

The sustainable harvest calculation does not include site-specific harvest plans that can be evaluated for their scenic impacts. Alternatives may, however, include different patterns of harvest at a landscape level. These potential effects are considered in the following paragraphs. Results for the six Alternatives are not a prediction of where and when harvest would occur under the different Alternatives. Rather, the outputs for each Alternative represent one of a number of potential paths to achieve the long-term objectives of that Alternative and are used in this analysis for comparison among Alternatives rather than an accurate prediction of the future. Given these constraints, the following analysis addresses the effects of the potential Alternatives in terms of the projected amount of land that would be subject to more intensive harvest and the projected amount of open forest under each Alternative. Potential negative effects on scenic resources are assumed to increase with harvest intensity.

Projected harvest under the proposed Alternatives is grouped into three harvest types (low-volume, medium-volume, and high-volume removal harvest) for the purposes of analysis. The percent of harvest type acres by decade is presented by Alternative in Figure 4.2-2, Section 4.2, Forest Structure and Vegetation. Average annual high volume removal harvest acres are presented by Alternative and decade in Figure 4.13-1.

These data indicate that high-volume removal harvest would occur more frequently under Alternatives 5 and 6 for all decades that make up the 64-year planning period with two exceptions. These exceptions occur in 2044 through 2053 when high-volume removal harvest would occur over a larger area under Alternative 3 than Alternative 5, and 2064 through 2067 when high-volume removal harvest would occur over a larger area under Alternative 3 than Alternative 6. High-volume removal harvest would occur over smaller areas under Alternatives 1 and 4 for all of the decades under consideration (Figure 4.13-1).

A second perspective is provided by considering the projected amount of open forest. Figure 4.4-1 in Section 4.4 (Wildlife) identifies the percent of total forest area in three groups of forest structure classes (ecosystem initiation forest, competitive exclusion forest, and structurally complex forest) under each Alternative. In the short term (2013), there is no meaningful difference among the Alternatives. In the long term, the amount of ecosystem initiation forest would be the largest under Alternative 5, followed by Alternatives 3 and 6, with Alternatives 1, 4, and 2 having the smallest amounts. Alternatives 3, 5, and 6 generally result in greater increases in open forest across all six

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planning units, with the exception of the South Puget Planning Unit where Alternative 6 produces smaller increases than most alternatives in both time periods, and Alternative 1 has higher increases than most.

These broad landscape-level measures provide some indication of the Alternatives that would have a higher potential to affect scenic quality based on the intensity of timber harvest, with Alternatives 3, 5, and 6 involving more high-volume removal harvest and resulting in larger amounts of open forest. However, lands managed for timber production under all Alternatives would be managed under DNR's visual management procedure (PR 14-004-080), which seeks to minimize potential impacts to scenic quality by managing harvest activities with respect to sensitive viewshed areas.

Potential visual effects associated with the proposed Alternatives may be mitigated on a case-by-case basis during operational planning prior to the initiation of harvest activities. Operational planning by DNR includes policies and procedures related to green-up, reforestation, and harvest unit size that contribute to the management of forested landscapes.



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4.15 CUMULATIVE EFFECTS

4.15.1 Summary of Effects

This section analyzes the cumulative effects of the Alternatives. The analysis examines the potential effects of proposed changes to policy and procedures in the context of the role DNR-managed lands play in resource management in western Washington. The analysis uses the modeling outputs to inform the public and decision-makers of the relative differences in potential cumulative effects. This analysis also allows DNR to assess relative risks that are illustrated using modeling outputs.

Landscapes in western Washington are characterized by a particular distribution of forest structures. The distribution of forest structures over time and space appears to be the basis of cumulative effects in the forest environment. It is generally recognized that forests with very large trees and structurally complex forests are currently scarce, and medium-sized closed forests are overabundant across all ownerships in western Washington. Therefore, forest management activities that contribute to the development of more structurally complex forest and less competitive exclusion forest at the landscape level would be expected to reduce cumulative effects.

All Alternatives are modeled as resulting in increases in structurally complex forest over time. However, the rates of change and amount of change vary among the Alternatives. All Alternatives project changes in forest structure that should change the current distribution of structural classes towards more complex forests. All Alternatives create a new balance of forest structure at the landscape level. This new balance suggests that there is little potential for contributing to adverse cumulative effects.

4.15.2 Introduction

Although cumulative effects are not defined in the Washington State Environmental Policy Act, they are defined in the Washington State Forest Practices Rules as “the changes to the environment caused by the interaction of natural ecosystem processes with the effects of two or more forest practices” (Washington Administrative Code 222-12-046). Because forest management activities are regulated under the Forest Practices Act, this definition is useful for purposes of this sustainable harvest calculation. Cumulative effects can result from multiple forest practices conducted over the same time period but dispersed spatially, or from multiple forest practices that are conducted at the same site over time.

This cumulative effects analysis uses a semi-quantitative approach that ranks watersheds on several key issues. These watersheds represent Washington DNR Watershed Administrative Units per March 2002 delineations. This analysis is a screening tool for discerning the potential for proposed activities on DNR land to result in adverse cumulative effects on fish, hydrology, water quality, soils, and wildlife. While it does not provide precise site-specific conclusions about the current or future existence of cumulative effects, the screening analysis does provide information on *what types* of cumulative effects might occur and *where* these effects might be most likely to occur. This approach is based on reasonably available information and avoids speculative conclusions.



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In this way, information contained in this analysis indicates where additional site-specific analyses in project-level planning may be appropriate.

4.15.2.1 Data Adequacy and Assumptions

Geographic Information System data were used to estimate current conditions over the landscape; this information was used to estimate where current conditions or levels of disturbance potentially place a watershed at higher risk for cumulative effects over the planning period. For example, high resource sensitivity may be identified for a variety of reasons, including, but not limited to, the presence of important and sensitive resources (e.g., bull trout), significant loss or significant disturbance of rare or uncommon habitats (e.g., old forest), or the presence of potentially triggering characteristics (e.g., unstable slopes or sensitive soils) that may materially affect a significant resource.

Several datasets were used in the analysis. Geographic Information System data, in combination with assumptions about activities on private, state, and federal forested lands, were used to examine the disturbance/condition level of watersheds and planning units, and the risk that DNR management activities may contribute to significant adverse cumulative effects. Assumptions about activities (such as rotation length and stream buffers) on private and federal forestland were based upon management strategies (Habitat Conservation Plans, the Northwest Forest Plan) and state law (e.g., Forest Practices Law, Rules, Standards and Guidelines). The risk of adverse cumulative effects was then based on the type of management and the degree of management intensity proposed under each Alternative. For example, watersheds with greater amounts of hydrologically immature forest would likely require more careful tactical and operational-level planning and analysis under Alternatives 5 and 6 than under Alternatives 1 and 4, because more frequent harvest activities are anticipated under Alternatives 5 and 6.

Vegetation data for this analysis were derived from maps developed by the Interagency Vegetation Mapping Project (2002). (The primary purpose of the maps is to serve as monitoring tools for the Northwest Forest Plan, which provides management direction for the USDA Forest Service and the USDI Bureau of Land Management.) The maps show existing vegetation, canopy cover, size, and cover type for the entire range of the northern spotted owl using satellite imagery from the Landsat Thematic Mapper. The Interagency Vegetation Mapping Project used a regression modeling approach to predict vegetation characteristics from the Landsat data.

Interagency Vegetation Mapping Project data do not identify stand development stages, but the data can be grouped based on tree size classes and percentage of conifer cover. Tree size classes were calculated using quadratic mean diameter, defined as the diameter at breast height of a tree of average basal area for the stand. Quadratic mean diameter was calculated in inches and was based on dominant and co-dominant trees only. The size class models were applied only to areas that met the minimum condition of at least 70 percent total vegetation cover and at least 30 percent conifer cover. Areas that did not meet these criteria (and thus were not assigned size class values) account for approximately 30 percent of the total area identified as forest vegetation. Size classes (in inches) were grouped as



follows: 0–10, 10–20, 20–30, and greater than 30. The Interagency Vegetation Mapping Project also identified total green vegetation cover, which includes trees, shrubs, and herbaceous plants. Areas with greater than 30 percent conifer cover were grouped into two classes: less than 70 percent, and 70 percent or more conifer cover.

The Interagency Vegetation Mapping Project data are considered the best available data for a landscape-level analysis encompassing all ownerships, and are considered accurate enough to permit analysis of potential cumulative effects at the watershed level. For the analysis of environmental impacts on state trust lands, DNR’s state land forest resource inventory system provides the most detailed information on vegetation cover.

4.15.2.2 Scale of Analysis

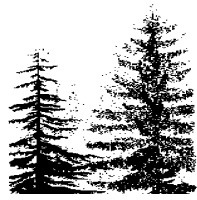
Cumulative effects are discussed at the planning unit level. References to the distribution of impacts among watersheds are made, as needed, to explain conditions within a planning unit. Tables summarizing conditions at the watershed level are presented in Appendix E. The analysis focuses on 179 watersheds in which DNR manages at least 5 percent of the watershed.

For each resource area, watersheds are ranked into quartiles (upper, upper mid, lower mid and lower) according to current conditions (see Appendix E for examples). Current conditions are represented with the best reasonably available data and information. The upper quartile is used to discern the highest relative potential for adverse cumulative effects; the rating is “highest” in a relative sense, not having any absolute or quantitative significance. Ranking a watershed in the upper quartile does not indicate that adverse cumulative effects are occurring or will occur. The upper quartile represents only a screening tool to assist in identifying the current condition of resources in specific locations that may be more vulnerable to potential cumulative effects.

The discussions below should not be interpreted as identifying watersheds where adverse cumulative effects may or may not be likely to occur. Instead, the data, within the context of a review of existing policy and procedures, serve as a screening tool for identifying areas where DNR land management may be most influential and, conversely, where consideration of resource protection may influence DNR operational planning. An example of the latter may be seen in the discussions of watersheds where northern spotted owl nesting, roosting, and foraging management areas have been designated. In watersheds where both forest with very large trees and federal reserves are scarce, forest management on DNR lands under its Habitat Conservation Plan may play an important role in meeting the goals and objectives for managing spotted owl habitat.

4.15.3 Vegetation and Wildlife Habitats

This section identifies areas where timber harvest on DNR lands may appreciably influence the availability of wildlife habitats and the species associated with them. As such, some of the tables and discussions below identify areas where certain habitat types represent a small proportion of the total area, and DNR lands contain a relatively large proportion of



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the amount that exists. In these areas, timber harvest on DNR lands may carry the risk of reducing the availability of a particular habitat type. The absolute significance of the reduction cannot be characterized with reasonably available data. Other tables focus on areas where DNR land management decisions may contribute to a sizeable increase in the distribution of one habitat type at the expense of others, or where DNR timber harvest may provide opportunities to increase habitat diversity in areas dominated by a single habitat type. Analyses in this section are based on three Appendix E tables that list the 179 westside watersheds in which DNR lands make up at least 5 percent of the total land area. Each of these tables (Appendix Tables E-4, E-5, and E-6) identifies the proportion of forested lands in each watershed consisting of a different forested habitat type, and the distribution of that habitat type among different land ownerships. A fourth appendix table, Table E-7, identifies the proportion of each watershed under DNR, federal, private, or other ownership.

The discussions below focus on three forest condition classes (small/open forests, forests with medium/large trees, and forests with very large trees) and one non-forested habitat type (wetlands). Wildlife species associated with the different forest habitat types are discussed in Section 4.4. Although the timber harvest activities addressed in this Environmental Impact Statement are not likely to affect the amount and distribution of a non-forested habitat such as wetlands, habitat quality may be adversely affected by equipment and activities associated with timber harvest (see Section 4.9). Significant regulatory (RCW 79.01 and Forest Practices Rules) and Habitat Conservation Plan protections exist for wetlands, both forested and non-forested, suggesting that the likelihood of significant impacts to these important habitats is low. Wetlands support a diverse assemblage of wildlife species and represent an essential habitat component for some. Riparian areas, which also play a vital role in the lives of numerous wildlife species, are addressed in the discussion of fish habitat quality in this cumulative effects analysis (Section 4.15.4).

Interagency Vegetation Mapping Project data were used to identify three broad classes of forested vegetation, which roughly approximate the forest habitat types used in other analyses in this Environmental Impact Statement. The small/open forests are most similar to early stages in the stand development, i.e., ecosystem initiation (Table 4.2.4). The 'medium-to-large diameter, closed forests' approximate the competitive exclusion stages described in Table 4.2.4, and the 'forest with very large trees' are most similar to the structurally complex forest stand development stages (represented by developed understory through old natural forests in Table 4.2.4). Note, however, that the classes in this cumulative effects analysis are defined using different criteria, and are based on a different set of data than the forest structure classes identified in Sections 4.2 and 4.4. Table 4.15-1 lists the criteria used to define the forest structure classes used in this analysis.

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Table 4.15-1. Definitions of Forest Structure Classes Used in this Cumulative Effects Analysis Based on Interagency Vegetation Mapping Project Data

Forest Condition Class	Interagency Vegetation Mapping Project Data Criteria
Forest with small-diameter trees, open forest	Conifer cover ^{1/} less than 70 percent and quadratic mean diameter less than 10 inches.
Forest with medium- to large-diameter trees, closed forest	All stands with a quadratic mean diameter between 10 and 30 inches, plus stands with conifer cover greater than 70 percent and quadratic mean diameter less than 10 inches.
Forest with very large-diameter trees	All stands with a quadratic mean diameter greater than or equal to 30 inches.

^{1/} As defined in Interagency Vegetation Mapping Project data documentation (2002)

The analysis of potential adverse cumulative effects to wildlife species associated with different forest condition classes examines the proportion of the forested area in each watershed comprising each forest condition class. For this analysis, the area identified by Interagency Vegetation Mapping Project data as vegetated areas (excluding agricultural areas) is taken to represent forested areas. As noted above, available data on canopy cover do not distinguish among coniferous, deciduous, shrubby, and herbaceous vegetation, so this analysis likely overestimates the amount of forested habitat in some areas. Also, size class data could be assigned only to areas with at least 70 percent total vegetation cover and at least 30 percent conifer cover. Forest condition class definitions are based on size classes, so areas that do not meet these criteria did not fall into any of the three forest condition classes. This may lead to some underestimation of the amount of forest in the small/open condition, because some recently harvested areas likely have less than 70 percent total vegetation cover and less than 30 percent conifer cover.

4.15.3.1 Small/Open Forest

Of the 179 watersheds addressed in this analysis, more than half (107) have between 10 percent and 20 percent of their forested area in small/open forest (Table 4.15-2). Only

Table 4.15-2. Number of Watersheds^{1/} With Small/Open Condition Forest by Habitat Conservation Planning Unit

Percent Small/Open Condition	Columbia	N. Puget	OESF	S. Coast	S. Puget	Straits	Total
<10%	3	10	7	5	0	4	29
10-20%	21	39	15	16	6	10	107
20-30%	12	11	1	3	8	4	39
30-40%	2	1	0	0	1	0	4
Total	38	61	23	24	15	18	179
<i>Average</i> ^{2/}	<i>19.1%</i>	<i>15.6%</i>	<i>13.2%</i>	<i>15.2%</i>	<i>21.9%</i>	<i>16.1%</i>	<i>16.6%</i>

Data Source: Cumulative effects forest structure data

OESF = Olympic Experimental State Forest

^{1/} The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

^{2/} Average = average percentage forested area in small/open condition



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four watersheds have more than 30 percent small/open forest, and 29 have less than 10 percent. The South Puget Planning Unit has the highest average percentage of this forest condition per watershed, and the Olympic Experimental State Forest has the lowest.

Of the 20 watersheds with the highest proportion of small/open forest (i.e., the top 20), 7 are in the Columbia Planning Unit, 6 are in North Puget, 6 are in South Puget, and three are in the Straits unit. None of the top 20 is in the South Coast unit or the Olympic Experimental State Forest. In nearly all of the top 20, the great majority of small/open forest occurs on private lands. The most obvious exception is Hamilton Creek (280106) in the Columbia Planning Unit, where federal and municipal lands account for 53 percent of the small/open forest. DNR lands contribute at least 40 percent of the small/open forest in two watersheds: Upper South Fork Toutle (260508) in the Columbia Planning Unit, and Deming (010226) in the North Puget Planning Unit. See Appendix Table E-4 for the percentage of forested area consisting of small/open forest in all 179 watersheds and the distribution of that habitat among different ownership categories.

Table 4.15-3 summarizes the distribution of habitat among ownerships in 26 watersheds that have a combination of a relatively high proportion of small/open forest (greater than 20 percent) and a large percentage (greater than 90 percent) of the total land area in either private or DNR ownership. The more extensive forest management activities on DNR lands, as are projected to occur under Alternatives 5, 3, and 6 and to a lesser extent under Alternative 2, combined with similar activities on private lands, may result in a situation where more than 50 percent of the area of these watersheds supports small/open forest. Such a large increase in this habitat type may provide temporary benefits to some wildlife species (e.g., foraging habitat for deer and elk, or breeding habitat for certain birds), but may reduce the availability of other forest types below acceptable levels. The more intensive management in these watersheds under Alternatives 5, 3, and 6 thus may carry greater relative risk to species that rely on interconnected areas of closed-canopy forest. However, of the three Alternatives mentioned (5, 3, and 6), the forest management strategies of Alternative 6 indicate substantially greater increases in more structurally complex forests than Alternative 1 (No Action). These increases in larger diameter and more structurally complex forest may mitigate for the potential loss of interconnected closed canopy-forest.

Table 4.15-4 portrays the opposite scenario to Table 4.15-3. It summarizes 20 watersheds in which 10 percent or less of the forested area consists of small/open forest. In addition, less than 30 percent of the total land area is in private ownership, that is, DNR and/or the federal government are the dominant landholders in these watersheds. Over time, passive management of DNR lands (such as is projected to occur in many areas under Alternatives 1 and 4), combined with passive management of federal lands, would result in declines in the amount of small/open forest in these areas. Conversely, more relatively intensive timber harvest on DNR lands (for instance, under Alternatives 5, 3, 2, or 6) may provide appreciable increases in the amount of this habitat type. Table 4.15-4, therefore, identifies potential opportunities for DNR to ensure that small/open forest continues to be available

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in all westside watersheds with an appreciable amount of DNR land. Abundant shrubby and herbaceous vegetation in such areas would provide foraging habitat for deer and elk, and support an abundant and diverse assemblage of birds (Carey et al. 1996).

Table 4.15-3. Percent of Small/Open Forest and Ownership in Watersheds^{1/} with the Highest Future Potential to Become Dominated by Small/Open Forest^{2/}

Planning Unit	Number of Watersheds	Average Percent Small/Open Forest	Average Percent of Watershed Area in Each Ownership			
			DNR	Federal	Private	Other
Columbia	6	25%	9%	0%	88%	3%
N. Puget	8	25%	20%	0%	79%	1%
OESF	1	21%	26%	4%	67%	2%
S. Coast	3	21%	40%	0%	59%	1%
S. Puget	5	23%	48%	0%	47%	5%
Straits	3	26%	27%	0%	71%	2%
Westside	26	24%	26%	0%	71%	2%

Data Source: Cumulative effects forest structure data

OESF = Olympic Experimental State Forest

^{1/} The term “watershed” is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

^{2/} Potential for domination by small/open condition forest based on the current percent of this forest condition and likely management based on ownership in a given watershed.

Table 4.15-4. Watersheds^{1/} Where Management of DNR Lands May Play a Major Role in the Maintenance of Small/Open Forest

Planning Unit	Number of Watersheds	Average Percent Small/Open Forest	Average Percent of Watershed Area in Each Ownership			
			DNR	Federal	Private	Other
Columbia	2	8%	25%	73%	2%	0%
N. Puget	9	7%	26%	54%	17%	3%
OESF	5	8%	23%	47%	27%	2%
Straits	4	7%	24%	54%	20%	2%
Westside	20	7%	25%	54%	19%	2%

Data Source: Cumulative effects forest structure data

OESF = Olympic Experimental State Forest

^{1/} The term “watershed” is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations



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4.15.3.2 Forests with Medium/Large Trees

Nearly three-quarters of the watersheds have at least 40 percent forested land in the forests with medium/large trees (Table 4.15-5). In one watershed in the North Puget Planning Unit (Cypress [030415]), 92 percent of the forested land area is in this condition.

Table 4.15-5. Number of Watersheds^{1/} Supporting Various Proportions of Forests with Medium/Large Trees Among Planning Units

	Columbia	N. Puget	OESF	S. Coast	S. Puget	Straits	Total
<20%	2	0	0	0	0	0	2
20-40%	9	16	2	9	3	9	48
40-60%	23	41	18	11	7	8	108
60-80%	4	3	3	4	5	1	20
80-100%	0	1	0	0	0	0	1
Total	38	61	23	24	15	18	179
<i>Average</i> ^{2/}	<i>44%</i>	<i>45%</i>	<i>51%</i>	<i>49%</i>	<i>49%</i>	<i>42%</i>	<i>46%</i>

Data Source: Cumulative effects forest structure data

OESF = Olympic Experimental State Forest

^{1/} The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

^{2/} Average = average percentage area of medium/large condition forest by planning unit

Table 4.15-6 summarizes the ownership distribution of forests with medium/large trees in the top 25 percent of the watersheds with the highest proportion of forests with medium/large trees. The upper quartile was chosen because this forest condition has the least benefit to a broad range of wildlife species groups (see Section 4.4) and indicates potential forest health impacts (Section 4.2.6). See Appendix Table E-5 for the percentage of the forested area with medium/large trees in all 179 watersheds, and the distribution of this forest condition among different ownership categories.

Overall, the average proportion of this forest condition on DNR lands equals the average proportion on private lands. In three planning units (North Puget, South Puget, and Straits) the average proportion on DNR lands exceeds that on private lands. This pattern differs from the ownership pattern for watersheds with high proportions of small/open forest (where private lands are generally the dominant ownership) and forests with very large trees (where federal lands are most common and DNR has the highest proportion of ownership in only 2 of the top 20).

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Table 4.15-6. Summary of Watersheds^{1/} Supporting the Highest Proportion of Forests with Medium/Large Trees, and the Proportion of the Watershed in Each Ownership Class

Planning Unit	Number of Watersheds	Average Percent of Forest with Medium/Large Trees	Average Percent of Forest with Medium/Large Trees in Different Ownerships			
			DNR	Federal	Private	Other
Columbia	9	60%	38%	20%	41%	1%
N. Puget	11	62%	35%	28%	33%	5%
OESF	9	59%	32%	16%	46%	7%
S. Coast	8	64%	42%	0%	52%	6%
S. Puget	6	62%	54%	8%	20%	18%
Straits	1	60%	69%	8%	22%	0%
Westside	44	61%	39%	16%	39%	6%

Data Source: Cumulative effects forest structure data

OESF = Olympic Experimental State Forest

^{1/} The term “watershed” is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

In all of the watersheds with a high proportion of forests with medium/large trees, active forest management may increase habitat diversity within stands and across the landscape. Forests with medium/large trees generally have low levels of structural (and thus wildlife habitat) diversity, and nowhere is this structure class at risk of disappearing from the landscape. All the Alternatives, including Alternative 1 (No Action), project a substantial decrease (30 to 50 percent) in this forest condition on DNR state trust forestlands. Heavy thinning (as under Alternative 5) may provide temporary benefits to species associated with forest in the small/open condition. Thinning prescriptions designed to enhance structural diversity (as under Alternative 6) may accelerate the development of forests with very large trees, providing benefits to wildlife species associated with the latter condition. Forests with medium/large trees would be expected to develop the characteristics of forests with very large trees under passive management (as under Alternatives 1 and 4), but may take longer than projected without active management to develop these characteristics.

4.15.3.3 Forest with Very Large Trees

Throughout the 179 watersheds addressed in this analysis, forest with very large trees is the least common of the three forest condition classes. Only three watersheds have more than 30 percent of their forested area in forest with very large trees (Table 4.15-7). Nearly two-thirds (118) have less than 5 percent forest with very large trees. Fifty-five of these have less than 1 percent of forest with very large trees. This type of forest does not constitute a majority of the forested habitat in any of the watersheds, nor does it anywhere exceed the amount of either of the other two forest condition classes.



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Table 4.15-7. Number of Watersheds^{1/} Supporting Various Proportions of Forest with Very Large Trees among Planning Units

Percent of Forest with Very Large Trees	Columbia	N. Puget	OESF	S. Coast	S. Puget	Straits	Total
<1%	14	15		22	4		55
1-5%	13	17	12	2	11	8	63
5-10%	8	9	6			7	30
10-20%	3	12	3			1	19
20-30%		6	1			2	9
>30%		2	1				3
Total	38	61	23	24	15	18	179
<i>Average</i> ^{2/}	3.4%	7.9%	8.0%	0.4%	2.0%	7.1%	5.3%

Data Source: Cumulative effects forest structure data

OESF = Olympic Experimental State Forest

1/ The term “watershed” is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

2/ Average = average percent of forested area with very large trees

Currently, forest with very large trees is not evenly distributed among the HCP Planning Units. Two planning units (South Coast and South Puget) have no watersheds with more than 5 percent forest with very large trees (Table 4.15-7). This habitat type is particularly scarce in the South Coast Planning Unit, where 22 of 24 watersheds have less than 1 percent forest with very large trees. In contrast, more than half (10 of 18) of the watersheds in the Straits planning unit have at least 5 percent forest with very large trees. The North Puget Planning Unit has the most watersheds with at least 10 percent forest with very large trees (20), while the Olympic Experimental State Forest has the highest percentage of forest with very large trees among all watersheds.

Of the 20 watersheds with the highest proportion of forest with very large trees (i.e., the top 20), the majority of this forest type falls on federal lands in all but two cases. The two exceptions are Spada (070216) and Lower Middle Fork Snoqualmie (070307), both of which are in the North Puget Planning Unit. In both cases, DNR lands provide the largest proportion of existing forest with very large trees, 64 percent and 45 percent, respectively. Fifteen of the top 20 watersheds are in the North Puget Planning Unit; the Olympic Experimental State Forest and the Straits Planning Units have two apiece, and the Columbia Planning Unit has one. In 15 of the top 20, more than 10 percent of DNR lands have been designated as nesting, roosting, and foraging management areas for spotted owls. See Appendix Table E-6 for the percentage of the forested area with very large trees in all 179 watersheds, and the distribution of this habitat among different ownership categories.

Over the long term, all Alternatives would maintain or substantially increase the area of structurally complex forests on DNR-managed westside trust lands (see Figure 2.6-4 in Chapter 2). Alternative 1 projects an increase in the area in structurally complex forests from 10 percent to 28 percent. Alternatives 2, 3, 4, 5 and 6 project an increase to 16, 13,

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29, 11 and 24 percent respectively, of structurally complex forest on the state trust forestland base over the life of DNR's Habitat Conservation Plan.

Designated nesting, roosting, and foraging management areas account for more than 10 percent of DNR lands in 37 of the 179 watersheds. In most of these, the majority of forest with very large trees falls on federal lands. The 13 watersheds summarized in Table 4.15-8 may be of concern because less than half of the existing forest with very large trees occurs on federal lands. However, in all Alternatives, the area of structurally complex forest is projected to increase in designated nesting, roosting, and foraging management areas. Alternative 5 projects the smallest increase of structurally complex forest in nesting, roosting, and foraging management areas—from 10 to 20 percent over the life of the Habitat Conservation Plan (to 2067) compared to the projected increase from 10 to 45 percent under Alternative 1. Alternative 6, with biodiversity pathways management, projects an increase to 55 percent, while more passive approaches in Alternative 4 project an increase to 39 percent of the nesting, roosting, and foraging habitat area that would be in structurally complex forest by 2067. Although these areas may be of concern under current conditions, all the Alternatives project increases in structurally complex forests.

Table 4.15-8. Summary of Watersheds^{1/} in which at Least 10 Percent of DNR Lands are Designated Spotted Owl Nesting, Roosting, and Foraging Management Areas, and where less than 50 Percent of Existing Forest with Very Large Trees Falls on Federal Lands

Planning Unit	Number of Watersheds	Average Percent of Forest with Very Large Trees	Average Percent of Forest with Very Large Trees in Different Ownerships			
			DNR	Federal	Private	Other
Columbia ^{2/}	2	4%	30%	14%	41%	15%
N. Puget	11	8%	45%	22%	31%	2%
Westside	13	8%	43%	21%	32%	4%

Data Source: Cumulative effects forest structure data

1/ The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

2/ In one of these Watersheds (Hamilton Creek - 280106), 27% of the existing very large forest occurs in Beacon Rock State Park, and is thus not likely to be harvested.

As noted above, in most of the watersheds with the highest proportion of forest with very large trees, the majority of that habitat occurs on federal lands. Table 4.15-9 summarizes the distribution of habitat among different ownerships in 11 watersheds where at least 10 percent of the forested area consists of forest with very large trees, and where at least 20 percent of that habitat is on DNR lands. In the short term (i.e., before additional habitat can develop on federal or DNR lands), relatively more intensive timber harvest on DNR lands (as under Alternative 5) in these watersheds could substantially reduce the amount and quality of habitat in forest with very large trees in some areas where this type of forest is comparatively plentiful.



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Table 4.15-9. Summary of Watersheds^{1/} in which at Least 10 Percent of Forested Lands Supports Forest with Very Large Trees, and Where at Least 20 Percent of Existing Forest with Very Large Trees Occurs on DNR Lands

Planning Unit	Number of Watersheds	Average Percent of Forest with Very Large Trees	Average Percent of Forest with Very Large Trees in Different Ownerships			
			DNR	Federal	Private	Other
Columbia	2	13%	38%	56%	7%	0%
N. Puget	7	15%	50%	38%	10%	2%
OESF	2	13%	64%	35%	0%	1%
Westside	11	14%	50%	41%	8%	1%

Data Source: Cumulative effects forest structure data

OESF = Olympic Experimental State Forest

^{1/} The term “watershed” is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

Fifty-five westside watersheds support little or no forest with very large trees (less than 1 percent of the unit). Intensive harvest of lands in any ownership might carry the risk of effectively eliminating this habitat type—and the species that depend on it—from those watersheds (Appendix Table E-6), except in areas where such habitats occur on land protected for other policy reasons such as riparian or slope stability. Often, small amounts of older age classes occur in riparian areas, where they routinely receive protection by the Forest Practices Act and the Habitat Conservation Plan.

4.15.3.4 Wetlands

Interagency Vegetation Mapping data do not identify all wetland areas. Wetlands are identified in fewer than half of the 179 watersheds addressed in this analysis, and they account for no more than 1.2 percent of the area of any single watershed. These are the best available data for an analysis of this scale, however, and serve as a screening tool for identifying areas where wetlands may be of particular concern.

Table 4.15-10 assesses watersheds where wetlands may face a higher risk of disturbance from land management activities. Interagency Vegetation Mapping Project data indicate that at least 10 percent of the land area consists of agricultural and/or urban lands. Wetlands on agricultural and urban lands may have been filled in or otherwise degraded and wetlands that persist may face an elevated relative risk. Additional effort may be needed to ensure that management on trust lands in these watersheds do not contribute to adverse cumulative effects on wetlands. DNR current policy (Forest Resource Plan No. 21), Habitat Conservation Plan, and current procedure (PR 14-004-110) specify that wetlands require significant protection, and stipulate no overall net loss of wetlands due to state land management. See Section 4.9 (Wetlands) for an assessment of the risks to wetlands from forest management activities.

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Table 4.15-10. Areas with an Elevated Potential for Development and Where Wetlands Have Been Identified

Planning Unit	Number of Watersheds ^{1/}	Average Area of Wetlands	Average Percentage of Land Area in Different Land Classes or Ownerships			
			Agriculture	Urban	DNR	Private
Columbia	9	0.04%	21%	5%	12%	83%
N. Puget	14	0.15%	16%	5%	19%	78%
S. Coast	9	0.18%	17%	3%	26%	72%
S. Puget	2	0.07%	3%	14%	23%	68%
Straits	1	0.01%	33%	2%	13%	62%
Westside	35	0.12%	17%	5%	19%	77%

Data Source: DNR MASK Geographic Information System layer

^{1/} The term “watershed” is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

4.15.3.5 Summary

The tables and discussions above identify watersheds with the greatest risks and opportunities associated with management of DNR lands under the six Alternatives. Table 4.15-8 identifies areas of relative concern with regard to northern spotted owl habitat management. All Alternatives project increases in structurally complex forest over time. However, the rates of change and amount of change vary among the Alternatives. All Alternatives project changes in forest structure that should change the current distribution of forested habitat types towards more structurally complex stands. The result is a potential reduction in the risk of certain types of cumulative effects over the long term. Alternatives that do not include specific strategies to enhance habitat and have higher rates of harvest than Alternative 1 (No Action), have a greater potential of reducing forest with very large trees in areas where it is relatively plentiful and is not protected or designated as a set-aside. Such protections and/or set-asides can be either policy (or contract in the case of the Habitat Conservation Plan) in nature or required by state or federal laws. Table 4.15-3 identifies areas where intensive forest management may cause the amount of small/open forest to become the dominant forest condition class on the landscape.

4.15.4 Fish

Several factors influence the potential for forest management to contribute to adverse cumulative effects to fish resources. These factors include the presence of fish or fish habitat, the existing condition of these resources, and the frequency and intensity of management activities. The location of management activities also plays a role. Activities in the riparian area may influence the potential for adverse effects, as well as those in upslope areas with the potential to deliver significant amounts of sediment into the aquatic ecosystems. Activities in areas of unstable slopes (and an elevated risk of mass wasting) may increase the potential for sediment delivery, while those in significant rain-on-snow zones may alter the timing and magnitude of peak stream flows.



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Areas that have more fish resources (as indicated by stream density) are considered to be potentially more sensitive to cumulative effects. Similarly, areas that have higher levels of disturbance (e.g., small riparian trees) or potential disturbance (unstable slopes) are considered to be potentially at higher relative risk of showing adverse cumulative effects currently or in the future. Finally, management strategies on different ownerships can result in different levels of future activities. Higher levels of activity are considered to have a higher relative potential to contribute to adverse cumulative effects. Federal ownership is expected to result in few forest management activities under the Northwest Forest Plan, while private forest ownership is expected to result in more intensive and frequent management. The level of forest management activities in riparian areas on DNR westside trust lands may be relatively lower (Alternatives 1 and 4) or relatively higher (Alternatives 5 and 6) depending upon the Alternative chosen.

In general, fish resources and their habitat are expected to improve in the long term because of the Northwest Forest Plan, improved Forest Practices Rules, various habitat conservation plans being implemented and developed in the region, and federal, state, and local programs. Each of these has a goal of protecting and restoring fish resources in the Pacific Northwest. Nevertheless, forest management activities will continue to occur in the region, and the risk of adverse cumulative effects needs to be evaluated in light of these activities, current conditions, and the previously identified legal and policy constraints.

The fish resource cumulative effects analysis uses the watershed as the spatial scale for assessing cumulative effects, and the planning unit as the scale for summarizing them. Only watersheds that have at least 5 percent DNR westside trust ownership were included in the analysis. The assessment is a screening tool for identifying the relative risk of cumulative effects. It is based on reasonably available information. It is not a precise determination of effects because the resolution of the available broad-scale data is inappropriate for a more precise assessment.

The cumulative effects analysis for fish resources integrates a number of measures for each watershed. These include:

- Percent of DNR trust land ownership in the total watershed area (Appendix Table E-7)
- Percent of riparian area with small trees (a quadratic mean diameter of less than 10 inches) (Appendix Table E-8)
- Anadromous fish stream density (stream miles per square mile) (Appendix Table E-9)
- Total stream density (stream miles per square mile) (Appendix Table E-10)
- Resident fish stream density (Types 1 to 3 stream miles per square mile) (Appendix Table E-11)
- Bull trout stream density (bull trout stream miles per square mile) (Appendix Table E-12)
- Percent of watershed area with urban or agricultural land use (Appendix Table E-13)



- Percent of rain-on-snow area with hydrologically immature forest (see Section 4.7, Hydrology) (Appendix Table E-14)
- Miles of stream on the 303(d) list for temperature (see Section 4.8, Water Quality) (Appendix Table E-15)
- Miles of stream on the 303(d) list for fine sediment (see Section 4.8, Water Quality) (Appendix Table E-17)
- Percent of watershed area assessed as having a high rating for shallow rapid landslides (see Section 4.6, Geomorphology, Soils, and Sediment) (Appendix Table E-18)

The available information (summarized in Appendix Table E-1) indicates that the highest average proportion of watersheds that was in the upper quartile for the measures described above was in the North Puget Planning Unit (about 42 percent), followed by the Olympic Experimental State Forest (about 17 percent), Columbia (about 16 percent), South Coast (about 14 percent), South Puget (about 6 percent), and Straits Planning Units (about 6 percent). The average proportion of watersheds within a planning unit that was in the upper quartile was highest for the Olympic Experimental State Forest (about 33 percent) followed by South Coast (about 26 percent), North Puget (about 24 percent), Columbia (about 19 percent), South Puget (about 17 percent), and Straits (about 14 percent). Based upon this summary information, the relative potential for existing adverse cumulative effects to fish resources is highest for the North Puget and Olympic Experimental State Forest Planning Units, moderate for the Columbia and South Coast Planning Units, and relatively low for the South Puget and Straits Planning Units. Individual watersheds may have a higher or lower potential for existing adverse cumulative effects to fish resources than these planning unit averages.

The relative potential of future adverse cumulative effects is related to current conditions and the intensity and type of future forest management activities in riparian areas. Consequently, the relative potential for future cumulative effects from activities on DNR-managed westside trust lands may be highest under Alternative 6 compared to other Alternatives. However, thinning dense stands of small and medium trees (trees under 20 inches in diameter) would improve riparian conditions over time. The forest management activities associated with the low-volume harvests in Alternative 6 are based on biodiversity pathways management and are likely to enhance and accelerate the development of fully functional riparian forests for a larger area in an earlier timeframe. Therefore, the relative risks of some adverse cumulative effects from tree removal and ground disturbance may be higher under Alternative 6 compared to Alternatives 1 through 4, which have relatively low levels of management activities in riparian areas. On the other hand, the current levels of adverse cumulative effects that result from having less-than-fully functional riparian areas are expected to decline more rapidly from active management under Alternative 6 compared to other Alternatives.

4.15.4.1 Evaluation of Potential Cumulative Effects to Fish

In all the Alternatives, riparian management activity on DNR state trust forestlands is designed to achieve stand development stages at and beyond understory initiation (see



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Table 4.2.4). Most of the riparian management activities would occur concurrent with adjacent upland forest management activities.

Based upon the current best reasonably available information, the relative potential for existing adverse cumulative effects to fish resources is highest for the North Puget Planning Unit, followed by the Olympic Experimental State Forest, Columbia, South Coast, South Puget, and Straits Planning Units. The relative potential of future contributions to adverse cumulative effects is assumed to be related to current conditions and the intensity and type of future forest management activities in riparian areas. Consequently, the relative potential for future cumulative effects from activities on DNR westside state trust lands may be highest under Alternative 6 compared to other Alternatives. However, in planning units that have large areas of small and medium tree (less than 20 inches in diameter) competitive exclusion forest in the riparian zones, for example the Olympic Experimental State Forest, the majority of harvest activities in riparian areas in Alternative 6 are low volume harvests to thin overstocked stands. The forest management activities associated with these low volume harvests in Alternative 6 are based on biodiversity pathway management and are likely to enhance and accelerate the development of fully functioning riparian forests for a larger area in an earlier time frame. Therefore, the relative risks of some adverse cumulative effects from tree removal and ground disturbance may be higher under Alternative 6, as compared to Alternatives 1 through 4, which have relatively low levels of management activities in riparian areas. On the other hand, the current levels of adverse cumulative effects that result from having less-than-fully functioning riparian areas are expected to decline more rapidly under active management.

4.15.5 Water Resources

4.15.5.1 Hydrology

Hydrologically mature forest is defined as a conifer-dominated forest having a relative density of at least 25 and a stand age of 25 years or older. Hydrologic immaturity is therefore any forested area that is younger than 25 years old, or that has a relative density of less than 25. The significant rain-on-snow zone varies with location, but typically is found between elevations of approximately 1,000 and 3,000 feet above sea level. Of the 179 watersheds in which DNR lands make up at least 5 percent of the total ownership, 159 of these also have areas of hydrologically immature forest in the rain-on-snow zones. These areas are summarized by ownership in Appendix Table E-14.

As discussed in the Forest Practices Rules Final Environmental Impact Statement (2001), Section 3.3, pages 3-27 and 3-28, three primary processes affect the hydrologic functions of forested watersheds: 1) precipitation and water flow regimes (i.e., flow with respect to time) largely controlled by climate; 2) the role of vegetation in intercepting precipitation and controlling the amount of water, including snow:rain ratio, that reaches the forest floor; and 3) the role of surface and subsurface pathways that deliver surface runoff and subsurface water to streams. Forest management can affect the hydrology of forested



watersheds by affecting annual water yield, low flows, and peak flows. Of these effects, the rate and types of harvest can significantly affect only peak flows. Changes in peak flows may lead to slope failure or increased incision and erosion of stream channels depending on local geomorphologic processes. These effects can be lessened by increasing the forest canopy within the watershed, and particularly by maintaining or increasing hydrologic maturity within the significant rain-on-snow zones.

4.15.5.2 Evaluation of Potential Cumulative Effects to Hydrology

None of the Alternatives would alter the amount of harvest allowable in the significant rain-on-snow zones or change the policies or procedures related to harvest. In all of the Alternatives, the percentage of mature forest on DNR lands within the “significant” rain-on-snow zones (the rain on snow and snow dominated zones) of watersheds would not drop below 66 percent, as defined in the Habitat Conservation Plan (page IV. 68) and procedure 14-004-060. As shown in Appendix Table E-14 and discussed in Appendix E, the Olympic Experimental State Forest has the largest percent of immature forest in the significant rain-on-snow zones under DNR ownership, meaning that this is the planning unit in which DNR carries the greatest relative risk for increasing peak flows relative to other ownerships.

Management intensity (indicated by decadal average values for acreage of high-volume harvest) and forest management activity type in the Olympic Experimental State Forest can be ranked by Alternative to address the potential for relative impacts to this area in terms of potential risk of increasing hydrologic immaturity in the significant rain-on-snow zones. Alternative 4 would have the least intensive management of the Olympic Experimental State Forest, approximately 800 acres per decade and would therefore require the least commitment of planning resources to prevent increases in peak flows. Alternatives 1 and 6 would essentially be identical in terms of high-volume removal harvest in the Olympic Experimental State Forest, with an average of approximately 5,200 acres per decade. Under Alternatives 2, 3, and 5, high-volume removal harvest would occur on an average of approximately 23,000, 22,000, and 31,000 acres per decade, respectively.

4.15.5.3 Water Quality

Water quality was evaluated in terms of the miles of stream listed under 303(d) for temperature, fine sediment, and dissolved oxygen in each of the 179 watersheds with greater than 5 percent DNR ownership. There were no 303(d) listings in these watersheds for phosphorous or other nutrients. The purpose of the analysis was to determine which planning units and watersheds were at risk for decreased water quality due to proposed changes in harvest levels on DNR lands. See Appendix E and Appendix E Tables E-15, E-16, and E-17.

4.15.5.4 Evaluation of Potential Cumulative Effects to Water Quality

As discussed in Section 4.8, Alternatives 2 through 6 would include increased harvest in riparian areas, meaning that there is relative risk of reduced shade and increased



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sedimentation in the short term with these Alternatives. While no harvest is proposed for the inner Riparian Management Zones in any of the Alternatives, Alternative 6 does include harvests of greater than 1 acre in Riparian Management Zones, which could increase the risk of blowdown, slightly increasing relative risk of fine sediment input to streams. Harvest intensity could affect the amount of road traffic, increasing the risk of fine sediment inputs to streams. Additionally, of the Alternatives proposed, only Alternatives 5 and 6 would increase fertilizer use. These two Alternatives have the highest relative risk for decreasing dissolved oxygen levels on listed streams. While the long-term and landscape level risks are low for water quality for implementation of any of the Alternatives, the 303(d) stream listings may be used as an allocation tool for planning resources to assess temperature and forest management interactions.

4.15.5.5 Slope Stability and Soils

Slope stability and soil productivity are critical variables in protecting the environment and maintaining harvest levels, as discussed in the Forest Practices Rules Final Environmental Impact Statement (2001) and this document. Both parameters are analyzed here based on slope stability, soil characteristics, and ownership data, and are discussed below.

4.15.5.6 Slope Stability

Slope stability has been modeled for all watersheds in the study area using the Shaw-Johnson model for slope stability (Shaw and Johnson 1995). Appendix Table E-18 contains data for areas classified as “high” for potential slope instability, and Appendix Table E-19 contains data for areas classified as “moderate” for potential slope instability. Evaluation using the Shaw-Johnson model is one of the methods used to initially identify areas of potential slope instability for DNR Procedure 14-004-050, Assessing Slope Stability. If this method is used to determine slope stability, the areas identified using the Shaw-Johnson model must then be field-verified by qualified staff. Harvest and management operations can occur in areas identified by the Shaw-Johnson model as having a high potential for slope instability, including those areas verified by field staff and determined in fact to have a high potential for slope instability based on field verified data. The current process for prevention of slope failure is a function both of identification of potentially unstable areas and careful planning of operations in those areas.

Slope stability rankings, as determined by the Shaw-Johnson model, vary regionally with topographic relief. The average percent area by watershed that is classified as high for potential slope instability is shown for each planning unit in Table 4.15-11.

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Table 4.15-11. Average Percent Area Classified as High for Potential Slope Instability by Planning Unit and Ownership

Planning Unit	Number of Watersheds ^{1/} Analyzed	Average Percent of Watershed Acreage Classified as High	Percent of Area Classified as High for Potential Slope Instability by Ownership			
			DNR	Federal	Private	Other
Columbia	38	7.5%	21%	13%	64%	1%
North Puget	61	17.1%	27%	36%	34%	2%
OESF	23	16.2%	39%	29%	28%	4%
South Coast	24	11.3%	27%	0%	70%	3%
South Puget	15	10.0%	38%	18%	39%	5%
Straits	18	13.5%	25%	50%	24%	1%
Average		12.6%	30%	27%	40%	3%

Data Source: DNR MASK Geographic Information System layer

OESF = Olympic Experimental State Forest

^{1/} The term "watershed" is used in this analysis to denote Washington DNR Watershed Administrative Units per March 2002 delineations

DNR ownership of these areas does not vary significantly among planning units from the average for DNR westside trust lands. The North Puget Planning Unit and the Olympic Experimental State Forest have the highest percent areas classified as high for potential slope instability as a result of modeling. Additionally, of 45 watersheds ranked in the top quartile for percent area classified as high for potential slope instability, nine have majority DNR ownership of these lands. These nine watersheds are in either the North Puget or Olympic Experimental State Forest Planning Units, as shown in Appendix Table E-18.

Existing DNR policies and procedures require specialist resources to identify any potentially unstable areas on which management is proposed. As the Shaw-Johnson model has not been calibrated for all areas on state trust forests in western Washington, the potential relative risks for proposed Alternatives is discussed qualitatively.

The actual risk of landslide should not increase under any of the Alternatives. Alternatives that propose higher levels of harvest in the North Puget Planning Unit and Olympic Experimental State Forest Planning Unit, and increased harvest intensity in general, could be considered to pose a slightly higher risk in terms of the necessity for additional resources devoted to assessment and planning for management activities on potentially unstable slopes.

Therefore, Alternatives are ranked from lowest to highest for the relative need to evaluate forest management activities on potentially unstable slopes by the amount of high- volume harvest area (expressed as the decadal average for the planning period) in the North Puget Planning Unit and Olympic Experimental State Forest as follows: Alternative 4 (10,000 acres), Alternative 1 (13,000 acres), Alternative 6 (20,000 acres), Alternative 2 (27,000 acres), Alternative 3 (31,000 acres), Alternative 5 (36,000 acres).



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4.15.5.7 Soil Compaction

Soil compaction can reduce site productivity by reducing the permeability and porosity of soil, making it more difficult for roots to penetrate the soil. Soil compaction can also influence hydrology by reducing the ability of soil to hold water. Soil compaction potential is a determination of the potential for moist soils to be compacted. Compaction of moist soils can occur during harvest. Harvest practices vary in the amount of compaction resulting in susceptible soils. Ground-based logging practices generally compact and disturb more soil area than practices using partial or full suspension. Policies and procedures in use by DNR to protect soil from compaction are discussed in Appendix C. Compaction effects from timber harvest may be short-lived, especially in coastal Washington, where reduced height of Douglas-fir in skid trail areas compared to non-skid trail areas was found to last only 2 years (Heninger et al., 2002).

Compaction potential varies regionally, with climate and soil type, but sensitivity of soils to compaction is a characteristic common to all of the 179 watersheds considered here for cumulative effects. Both “high” and “moderate” rated moist soil compaction potential data were analyzed, but only high compaction potential soil areas are discussed here. See Appendix Tables E-20 and E-21 for the analysis of all 179 watersheds.

Table 4.15-12 shows the percent area of planning units that has soils classified as high for potential for moist soil compaction. Four of the six planning units, and therefore a majority of the total area, are dominated by soils classified as high for moist soil compaction.

Table 4.15-12. Average Percent Acreage Classified as High for Moist Soil Compaction Potential

Planning Unit	Average Percent Acreage Classified as High	Percent of Area Classified as High for Potential for Soil Compaction by Ownership			
		DNR	Federal	Private	Other
Columbia	64%	20%	1%	77%	2%
North Puget	57%	32%	3%	62%	3%
OESF	62%	39%	3%	55%	4%
South Coast	89%	31%	0%	64%	5%
South Puget	27%	38%	1%	49%	11%
Straits	18%	37%	4%	57%	2%

Data Source: DNR MASK Geographic Information System layer
OESF = Olympic Experimental State Forest

Of the 45 watersheds in the top quartile for percent area classified with a high potential for moist soil compaction, all have at least 83 percent of their area classified as high for this parameter. Therefore, it can safely be assumed that in those 45 watersheds, there is a high probability that any planned harvest would occur on soils that could be considered at risk for compaction during moist soil conditions, regardless of ownership.

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A total of 107 of the 179 watersheds evaluated have greater than 50 percent soils rated as having high moist soil compaction potential. Of these, DNR owns 50 percent or more of the watershed area identified as having high moist soil compaction potential in 17 watersheds. Of these, 6 watersheds rank in the top quartile for percent area classified as high for moist soil compaction potential, as shown in Table 4.15-12. These would be the watersheds in which DNR's activities would have the most relative influence in terms of maintaining soil productivity and function in the watershed.

DNR policies and procedures described in Chapter 2 and Appendix C give general guidance for harvest to prevent unnecessary compaction as a result of harvest. As a result of this guidance, the relative risk of increased soil compaction is generally low, regardless of Alternative. The majority of the watersheds in which DNR manages more than 5 percent of the land area are dominated by soils classified as high for potential moist soil compaction. In addition, more intensive harvests would likely result in a greater amount of compaction. Therefore, the relative risk of compaction under each Alternative would be a function of two main factors: 1) total acreage disturbed by higher volume removal harvest activities (greater than 20 thousand board feet per acre) on moist soils, and 2) total acreage disturbed by all harvest activities. The Alternatives can be ranked from least to greatest risk for potential soil compaction as follows: Alternatives 1 and 4 would be essentially the same, followed by Alternatives 2, 3, 6, and 5.



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